9 High Nature Value Farmland

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9.1 Introduction

Previous work (Parrachini *et al*., 2008) carried out at the European scale and within Wales looked at the concept of High Nature Value farmland and how it might be defined and applied. HNV farmlands have been defined as *'areas in Europe where agriculture is a major (usually the dominant) land use and where that agriculture supports or is associated with either a high species and habitat diversity or the presence of species of European concern or both*' (Anderson et al. 2003, Beaufoy et al. 1994, Lomba et al. 2014). Low intensity agricultural practices may be important in maintaining these areas of high diversity or they may exist despite the farming activities. Spatial heterogeneity is important with habitat mosaics and different structural elements e.g. scrub and linear features to be considered. Land which is of 'High Nature Value' is not easily defined, it may be a subjective and contentious exercise choosing which elements best represent 'high value'. Within the EU, Member States are committed to identifying and maintaining HNV farming; however, there are no specific rules or generic metrics and criteria established at EU level to determine HNV farmland. Each member state therefore interprets the concept and decides how best to apply it to their state. It is inevitable that there will be disparities in HNV farmland definitions, individual countries will have different indicators (particularly for type 3 indicator species), farming systems and landscape features, however, there is a need for a more integrated approach across European countries with common standards and definitions (Lomba et al. 2014).

The GMEP team have been tasked by WG to explore these concepts and propose new ideas, criteria and metrics that might be applied to define land of 'High Nature Value' and to form an indicator to create a baseline extent and to measure changes in extent and quality. We are conducting this work in consultation with a range of partners and stakeholders who are also interested in the potential value of this metric. Specifically this has included a small working group involving CEH, BTO, RSPB and WG who first met in April 2013; a RSPB workshop with a wide range of participants from across the farming and conservation section in May 2013; a GMEP Steering Committee in June 2013 with representative from the farming community, WG, NRW and NGOs and a number of subsequent working group meetings in 2013/2014. A wide range of views were expressed which range from this "is a metric of little value which could confuse rather than illuminate" to "a potentially useful metric to communicate overall trends in biodiversity".
It has been generally agreed that HNV farmland (e.g. Andersen *et al.* 2003) can be broken down into 3 types:
Type 1: Farmland with a high proportion of semi-natural vegetation
Type 2: Farmland with a mosaic of habitats and/or land uses
Type 3: Farmland supporting rare species or a high proportion of European or world populations
And Not HNV: Typically the major arable areas, intensively managed land.
Type 3 may overlap with types 1 and 2 but some rare species may be associated with biologically simplified agricultural areas with low habitat diversity.

In their paper Lomba et al. (2014) present an extremely useful conceptual framework based on work by Andersen et al. (2003) and modified according to Parrachini et al. 2008, Oppermann et al. 2012, Pedroli et al. 2007). This figure also incorporates the gradient in farming intensity with a threshold where land is no longer considered to be HNV, this could be particularly problematic in type 3 land where there are small pockets of rare species in an intensively farmed landscape.

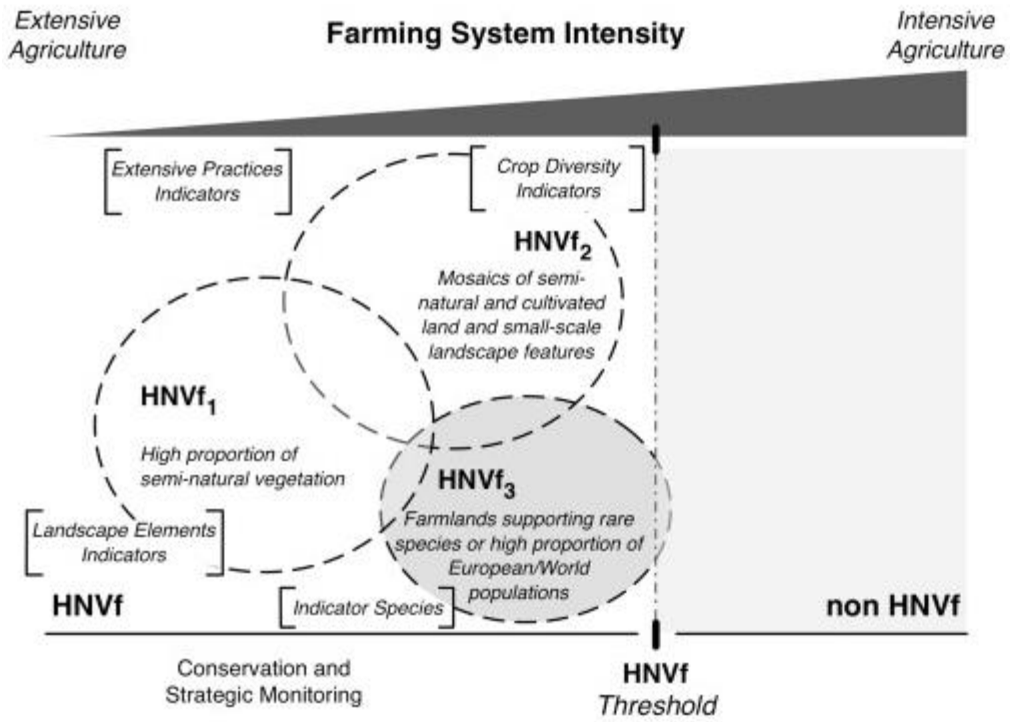

Fig. 9.1.1 *Taken from Lomba et al. (2014) High Nature Value farmlands (HNVf) conceptual framework in relation to the intensity of farming systems, and features underlying the classification of the three broad types as proposed by Andersen et al. (2003).*

The Common Monitoring and Evaluation Framework (CMEF; EC 2005) includes Baseline, (area of land under HNV) Result, (total hectares under successful land management) and Impact (changes in extent and condition indicators) and these need to be incorporated into planning for reporting on HNV.

It is important to create a metric structure that uses objectively measured criteria. In particular the temporal aspect needs to be considered, detection of change is important. Much of the data that could be used to derive indicators is not consistently collected at regular temporal intervals, so even if an estimate of HNV extent across Wales is created from the best available data a method for repeating this needs also to be developed. GMEP is a sample based monitoring system, the sampling system is a stratified random system which was used specifically to enable scaling up and creation of national estimates. If similar metrics are used only within GMEP 1km survey squares then with continuous monitoring from GMEP it will be possible to estimate changes in the HNV farmland metric even when it is not possible to repeat continuous national surveillance. Although it is also possible that it may be possible to obtain some of the other spatially continuous datasets e.g. remotely sensed land cover data (Morton and Rowland, 2014) on a more systematic and regular basis.

The need for options to prevent the loss of High Nature Value farmland is widely acknowledged (Parrachini et al. 2008) as part of the Habitats and Birds directives and rural Development Policy. The challenge is to identify such land based on consistently collected data, at a suitable resolution and then review if the information provides a useful addition to the reporting system for GMEP.

9.2 Achievements in Years 1 and 2

- Convened and met with a range of stakeholders to discuss possible approaches and agree a way forward

- Collated a table of possible metrics for HNV
- Collation of potential datasets from which to calculate metrics
- Development and calculation of metrics e.g. connectivity, habitat diversity, rare species, rare soils etc.
- Analysis and discussion of the potential to downscale from coarse resolution recording datasets- dataset for plant species produced
- Metrics calculated for four case study areas with proposals presented for next steps
- We present several methods of potentially assessing the contribution of soil to High Nature Value land.

9.3 Approach

There have been a number of meetings with stakeholders to discuss the concept of HNV and how we might develop an indicator in the Glastir Monitoring and evaluation project resulting in some decisions in scope and terminology and proposals for future work. A small working group involving members of the GMEP team (CEH, British Trust for Ornithology (BTO) and Staffordshire University), Royal Society for the Protection of Birds (RSPB), National resources Wales (NRW) and the Welsh Government (WG) was convened in April 2013 and met several times in 2013 and 2014. It was agreed that:

- The term HNV farmland would be used rather than HNV farming, farm type has been looked at in previous case studies (e.g. WG, Natural England (NE)) but its usefulness has been questioned so the type of farming will not be included in a classification system.
- The concept of HNV forestry would not be pursued as there appeared to be a move away from this as a requirement by the EC.
- We should keep it simple – there is flexibility in the guidance which means that we have flexibility
- The stakeholders and GMEP project team were asked to propose criteria and datasets that might contribute to an indicator and we have constructed a summary spreadsheet resulting from this consultation which links criteria to metrics and datasets.
- It was agreed that it would be useful to look at case study areas for HNV that the HNV topic group were familiar with

Indicators were investigated for mapping Types 1, 2 and 3 HNV farmland. The metrics that were considered included: percentage of semi-natural habitat, habitat richness (total number of habitats), habitat diversity (Simpsons and Shannon indices), habitat evenness, mean patch size, area of priority habitat, density of linear features (e.g. Hedgerows), connectivity for different species/habitats, and species data from BRC and BTO. A range of different datasets, available for calculating each of these indicators, was considered.

Four case study areas were selected: Conwy Valley, Carmarthenshire, Brecon Beacons National Park and Llyn Peninsula. Conwy Valley is already a CEH study area so there is existing knowledge and data for the area. East Carmarthenshire was part of a pilot HNV study (EFCNP). For each of the potential HNV indicators, maps were produced for the whole of Wales and for each of the four case study areas.

9.3.1 Available habitat/land cover data

There are a number of datasets available for mapping habitat/land cover across Wales, which have the potential to be useful for monitoring HNV farmland. These datasets are summarised in Table 9.3.1.1

Dataset	*Characteristics*
CCW/NRW Phase 1	• *Records priority habitats* • *Continuous data* • *Last surveyed 1999* • *Unlikely to be repeated so cannot be used for change*
Land Cover Map 2007 (LCM2007)	• *No priority habitats* • *Continuous data* • *Available to use now* • *Historical algorthims being standardised to allow for historic change to be more accurately reported* • *Rolling LCM under development which would allow use for change at more frequent time period*
Fused habitat map for Wales	• *Records priority habitats* • *Not consistently recorded- different rule bases applied in different areas* • *Not yet available?* • *Unlikely to be able to report change*
GMEP 1km survey squares	• *Fine detail, including linear features* • *Can use Glastir management data to look at impacts of options* • *Can be used for change* • *Sample based data*
Woody Cover Product (Section 5.4)	• *maps woody features that support biodiversity (hedges, individual trees, clumps of trees) and complements LCM* • *repeatable*

Table 9.3.1.1 *Summary of available datasets for mapping habitat/land cover across Wales*

9.4 Approach

The potential indicators have been assigned to different HNV types and presented under those sections with discussion. For HNV type 1 this is fairly straightforward and only one indicator is currently proposed, however for other HNV types data may be more complex and methods for combining metrics are also discussed.

9.5 Type 1 HNV: Proportion of semi-natural habitat

The proportion of semi-natural habitat in the landscape is an important indicator of biodiversity and of Type 1 HNV farmland. Land cover data from LCM2007 was used to calculate the percentage of semi-natural habitat (% SN habitat) in each $1km^2$ across Wales. Appendix 5.5 gives a list of the LCM2007 classes that were considered to be semi-natural.
The % SN habitat was calculated as:
% SN habitat = (area of semi-natural habitat)/(total area of habitat)x100
The resulting map is show in Figure 9.5.1

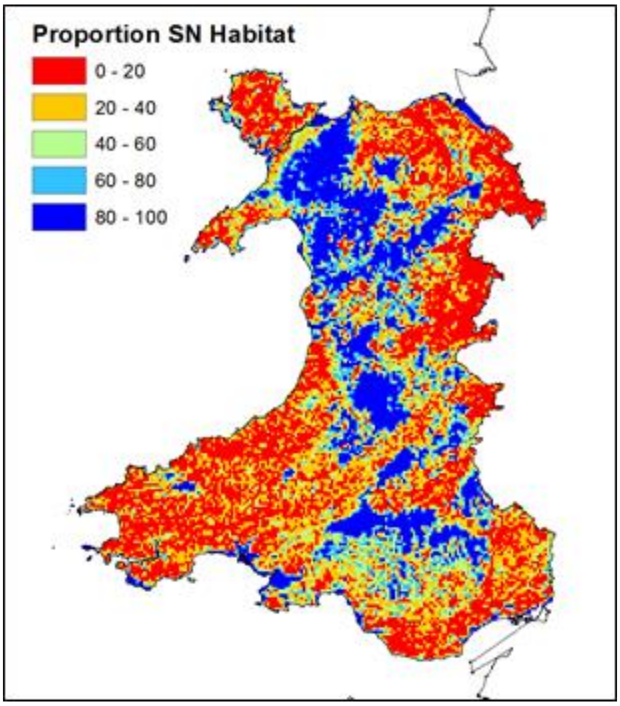

Figure 9.5.1 *Map showing the proportion (%) of semi-natural habitat in each 1km² across Wales based on LCM2007.*

9.6 Type 2 HNV: Farmland with a mosaic of habitats and/or land uses

9.6.1 Landscape heterogeneity

A number of indicators for landscape heterogeneity were considered for identifying Type 2 HNV farmland, including: habitat count; habitat diversity (Shannon and Simpsons indices) and habitat evenness. These indicators are calculated based on LCM2007 using similar methods to Hill & Smith (2005). The resulting maps are shown in Figure 9.6.1.1.

1. Habitat count (C): Total number of habitats per 1km^2 grid cell
2. Habitat diversity – Simpson's Index (D_{si}):
$$Simpson's = \sum p_i^2$$
3. Habitat diversity – Shannon's Index (D_{sh}):
$$Shannon's = -\sum p_i \ln p_i$$
4. Habitat Evenness (E):
$$E = D_{si}/C$$

N.B. Simpson is an inverse index

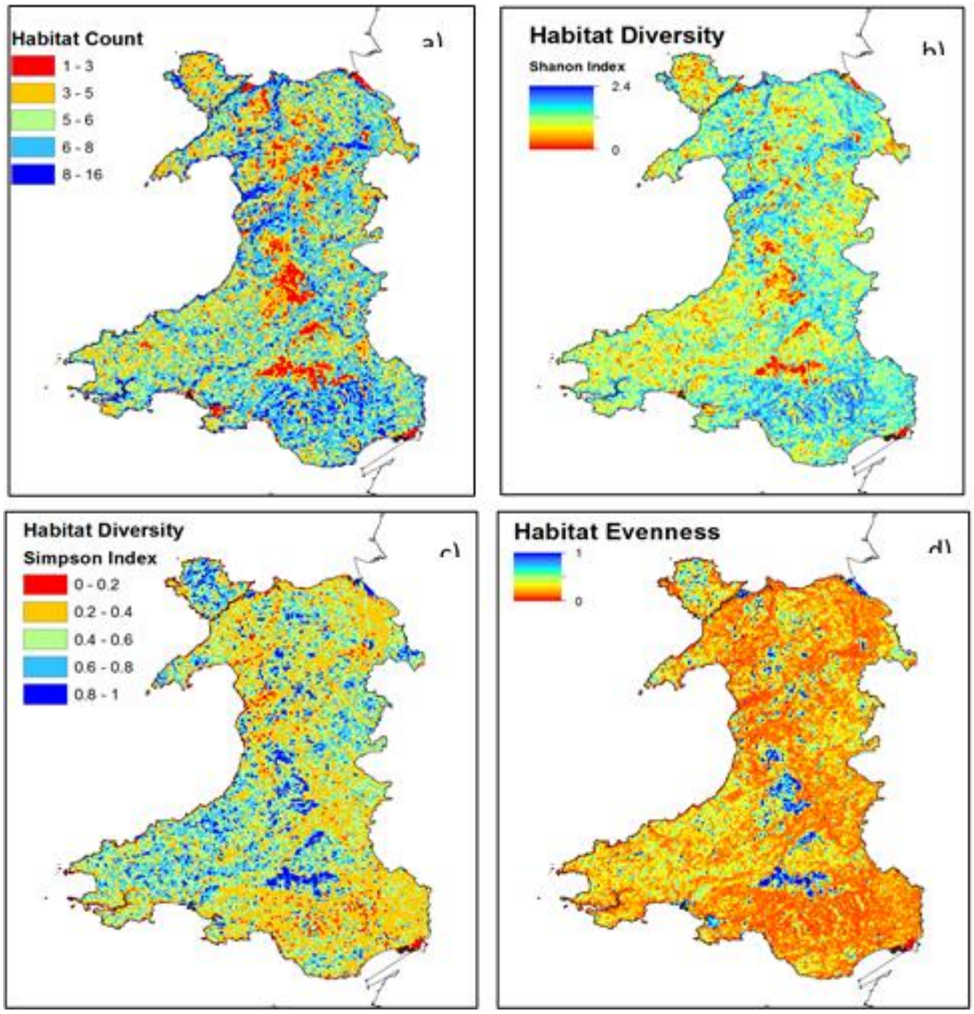

Figure 9.6.1.1 *Maps of habitat count (a); habitat diversity - Shannon index (b) and Simpson index (c); and habitat evenness (d), for each 1km² across Wales based on LCM2007.*

9.6.2 Woodland connectivity for HNV

Connectivity between habitat fragments is important to maintain species populations and diversity. Highly connected habitats allow species to move around with ease and can support a greater number of species. Connectivity is under threat through the fragmentation of habitats in the landscape as a result of agriculture or urbanisation. Connectivity is a component of Type 2 HNV and was assessed for Broadleaved woodlands in the four case study areas (Brecon, Carmarthenshire, Conwy and Llyn). To assess variation in connectivity over the case study areas the areas were divided into 1 km² grid cells. The distribution of Broadleaf woodland in case study area was mapped using the Land Cover Map for 2007. For each grid cell the pairwise distances between all the woodland habitat patches from Land Cover Map were calculated using the Conefor Inputs tool (Jenness Enterprises, Flagstaff, AZ, USA). These distances were then used as input to the Conefor tool (Saura & Torné, 2009) which calculated a connectivity metric (Probability of Connectivity) for each 1 km² in each case study area[1]. The connectivity metric was rescaled to between 0 and 1 to look at relative differences between grid cells.

[1] The tool was parameterised with a dispersal kernel with a distance of 200 metres at a probability of 0.5.

__9.6.3 Density of field boundaries__

Type 2 HNV farmland can be defined as a mosaic of low intensity farmland and other semi-natural landscape features. The density of field boundaries (which is inversely related to parcel size) is a proxy for management intensity. In general, smaller fields are likely to be less intensively managed. Figure 9.6.3.1 shows the density of field boundaries across Wales. Areas with high field boundary density, for example in the Llyn Peninsula, are potential areas of Type 2 HNV farmland. A similar metric could be produced which captures the density of woody linear features, work is ongoing to produce a Woody Linear Product which could be used for this purpose.

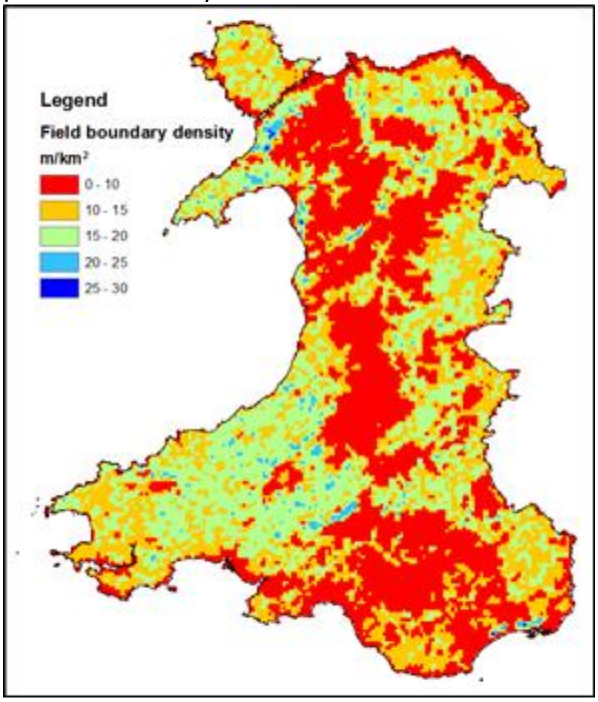

Figure 9.6.3.1 *Map of field boundary density across Wales, based on data for the Land Parcel Information System (LPIS).*

__9.6.4 Species__

Following meetings with stakeholders, it was felt that species data should be incorporated into the metrics for Types 2 and 3 HNV farmland. The following BRC species datasets at 10km resolution were assembled: Ants, Bees, Craneflies, Carabidae, Centipedes, Millipedes, Cerambycidae, Hoverflies, Isopoda, Ladybirds, Fish, Orthoptera, Bryophytes, Higher Plants, Birds. Figure 9.6.4.1 shows example maps produced using these data.

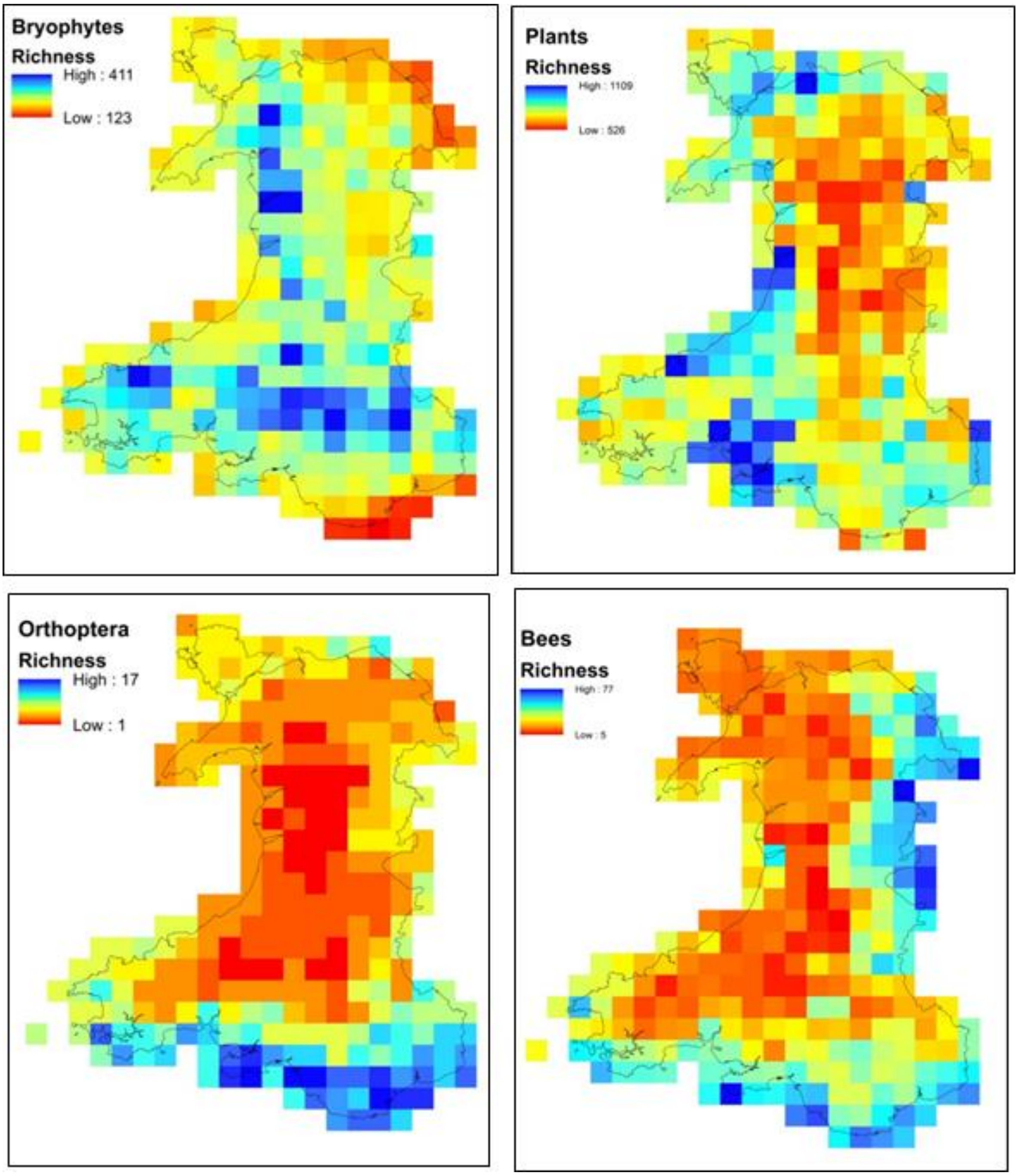

Figure 9.6.4.1 *Example maps of species richness within each 10km x 10km grid cell across Wales for different groups of species, based on BRC data.*

It is also possible to use bird data and there are various choices to make in creating a metric. Should a selection of bird species be used or should all bird species be included? It is possible to summarize the bird data in multiple ways – total abundance, various diversity indices. Here, a simple approach has been taken, avoiding decisions about how to combine species data to represent HNV best that have no clear evidential basis.

Figure 9.6.4.2a shows the distribution of conservation-relevant farmland bird species from the Bird Atlas 2007-11[2] and Figure 9.6.4.2b shows the distribution of all bird species, in each case

[2] All birds from the lowland and upland farmland lists for the standard indicator set, plus other S42 species (e.g. corn bunting) that are classified as "farmland" at UK level but too rare to be used in the Wales indicators. The species list is: Buzzard, Corn Bunting, Chough, Curlew, Grey Wagtail, Goldfinch, Greenfinch, Jackdaw, Kestrel, Lapwing, Linnet, Meadow Pipit, Grey Partridge, Reed Bunting, Raven, Rook, Skylark, Stock Dove, Starling, Tree Sparrow, Wheatear, Whinchat, Whitethroat, Woodpigeon, Yellowhammer, Yellow Wagtail.

summarized as simple species richness (the number of species per square found and interpolated from Bird Atlas 2007-11, Balmer et al. 2013). This data is at a 4km resolution which should be adequate for birds as they are mobile species and have varying range sizes.

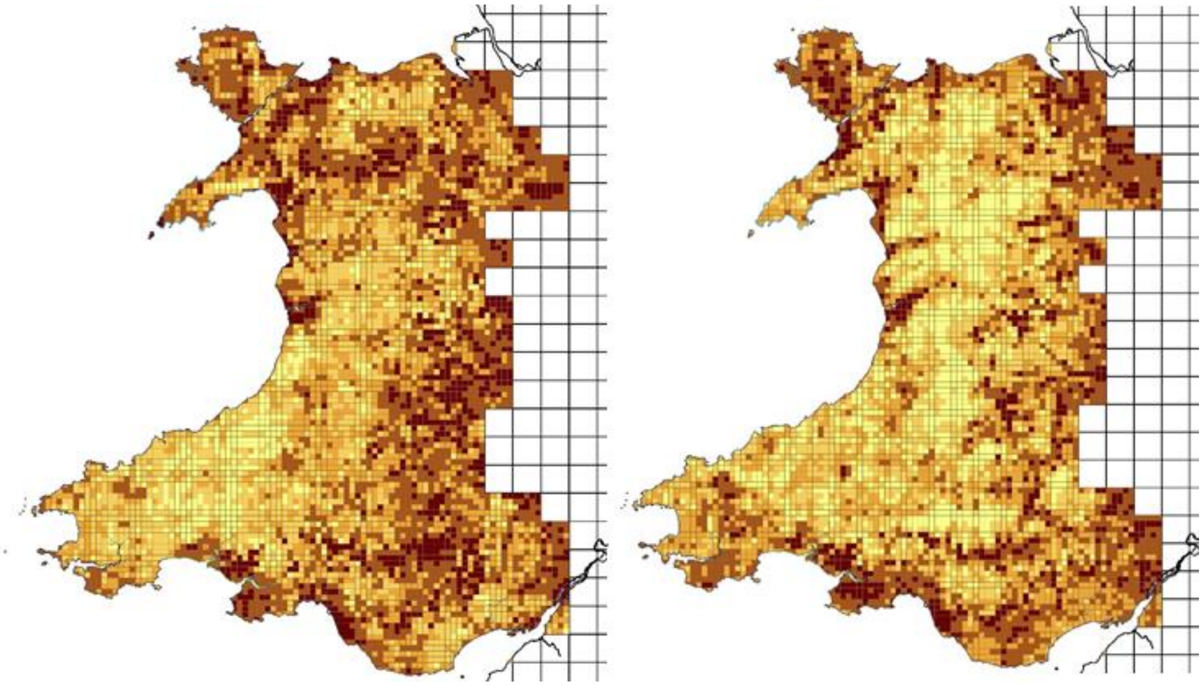

Figure 9.6.4.2a *(Left) richness of farmland bird species at a 4km square resolution*
Figure 9.6.4.2b *(Right) richness of all bird species at a 4km square resolution*

It would seem more appropriate to use the richness of farmland bird species (i.e. the number of species found within a defined area) as the metric to incorporate to identify HNV farmland. The coarse resolution of some datasets (hectad) makes it difficult to incorporate them into a metric for monitoring HNV farmland, small scale differences in species abundance are important. Work has taken place in GMEP to investigate the potential of downscaling (and upscaling) species data and plant species data is now available at 1km resolution. The technique used for the plants requires species-specific habitat associations mapped to the land cover map categories. This is not available for many groups, e.g. the pollinators. Work is ongoing using recently developed Bayesian techniques to develop datasets at a 1km resolution for other groups, however they are very computationally intensive and take a long time to run. Hopefully some progress will be made in this area to enable the use of finer scaled species data for a number of groups. It is possible to use some field survey based data for rare species (see section below).

9.6.5 Combining metrics

9.6.5.1 Ordination and response curves

Deciding how to identify High Nature Value areas is difficult because there will be variation in the relationships between diversity variables e.g. high plant species richness may not be correlated with high richness of bees, and agreement on prioritisation or optimisation of diversity will need to be decided between stakeholders. It is important to understand these relationships both at a national scale across Wales (Figure 9.6.5.1.1) and in individual case study areas (Figures 9.8.2.1a to d) to identify where there are tradeoffs and co-benefits. The figures below are created by carrying out a Principal components analysis (PCA) in R using the vegan program on standardised biodiversity metrics (scaled from 0 to 1 instead of using real values), these appear as the coloured curves in the figures below. Potential explanatory variables; Habitat diversity, NPP and connectivity have been included. A similar method was used in Maskell et al. (2013) to look at relationships between ecosystem service indicators.

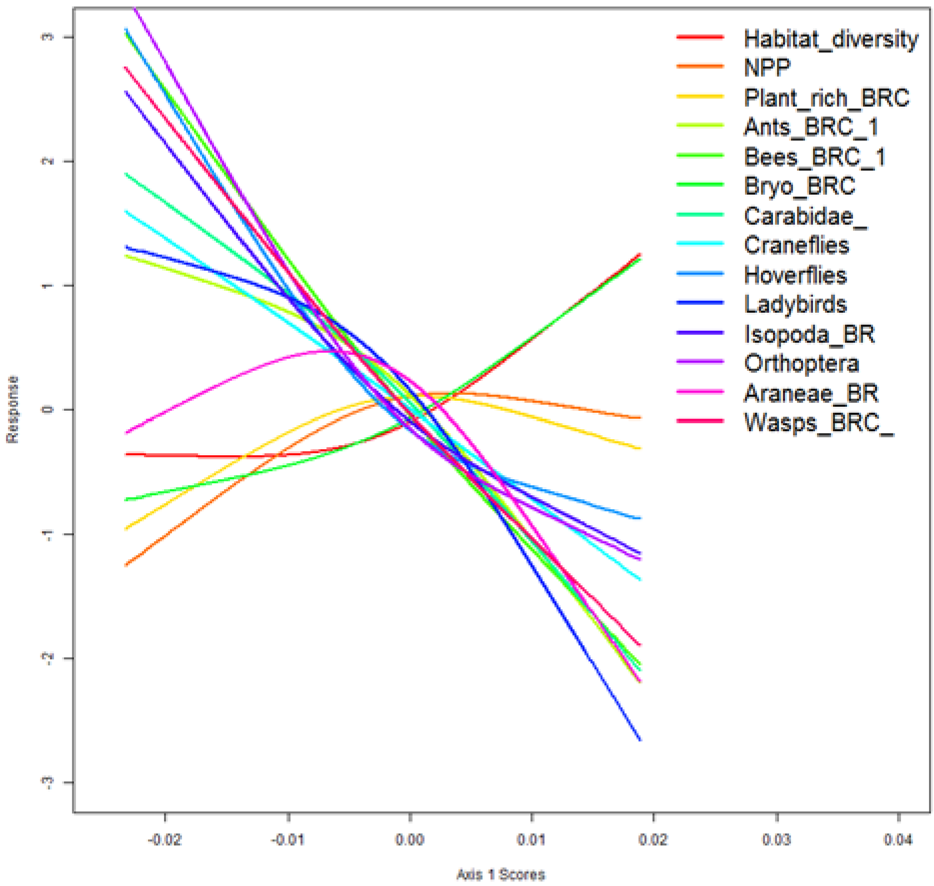

Figure 9.6.5.1.1 *Relationships between diversity variables across all of Wales.*

Figure 9.6.5.1 shows that relationships between biodiversity variables, NPP and Habitat diversity are complex. At a national scale there is an overall loss of biodiversity with increased productivity (NPP) and Habitat diversity, with some association between habitat diversity and bryophyte richness. Many of the species groups e.g. carabidae, hoverflies, bees, ants decline with habitat diversity but it must be remembered that data for all species other than plants is at a crude 10km resolution. This type of analysis needs to be repeated with the best possible data when more progress has been made at downscaling. A metric for HNV can be obtained by extracting the ordination score and using that as a single measure.

9.6.5.2 Other methods for combining metrics

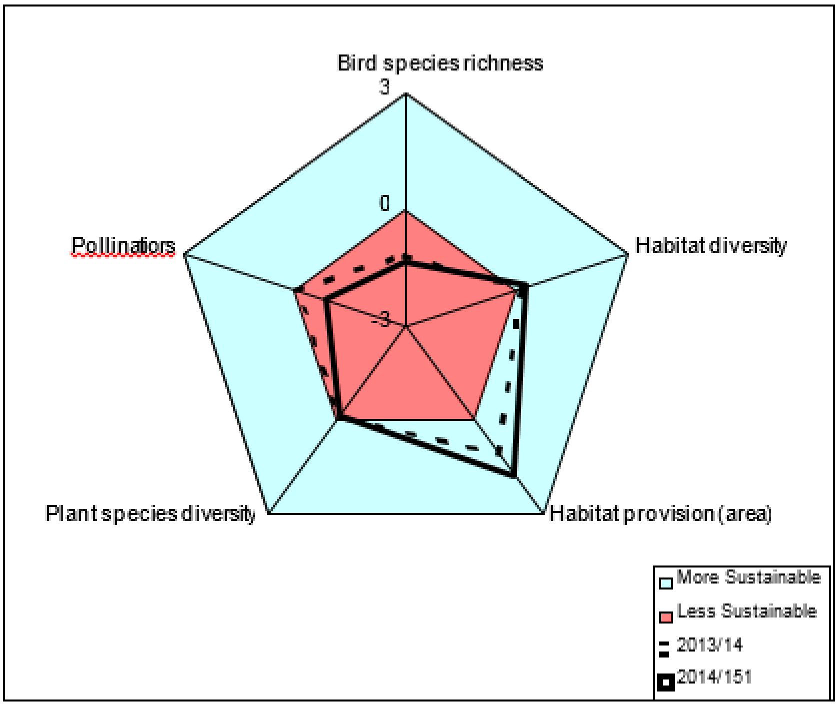

Figure 9.6.5.2.1 *Spider diagram of selected metrics/ecosystem services*

Figure *9.6.5.2.1* is a spider diagram of chosen metrics/ecosystem services, it uses a similar principal to the ordination, that you are using multiple indicators to indicate the condition of your HNV area and that there will be tradeoffs and co-benefits. The single metric could be the area contained within the graph shown here by the dashed and solid lines for different years, so for 2014/15 there is a larger provision of habitat but other indicators pollinators, plant species diversity, bird species richness there have been declines, the coloured areas reflect how sustainable the underlying resources are i.e. in this diagram some indicators have declined critically.
For both the ordination/response diagrams and the spider diagrams the choice of metrics can be discussed and the most appropriate agreed, these may include ecosystem variables such as soil quality (discussed later) in addition to diversity. Once we have chosen the most suitable metrics at the most appropriate resolution analyses can be carried out to create an HNV metric. An ordination method was used by Boyle et al. 2015 to create an index score based on selected variables in a study in Ireland.

9.7 Type 3 HNV farmland: Farmland supporting rare species or a high proportion of European or world populations.

9.7.1 Species

It is possible to use data on rare species from field survey/monitoring schemes. Figure 9.7.1.1 shows the distribution of Section 42 plant species taken from data provided by Plantlife. Figure 9.7.1.2 shows the distribution of rare bird species.

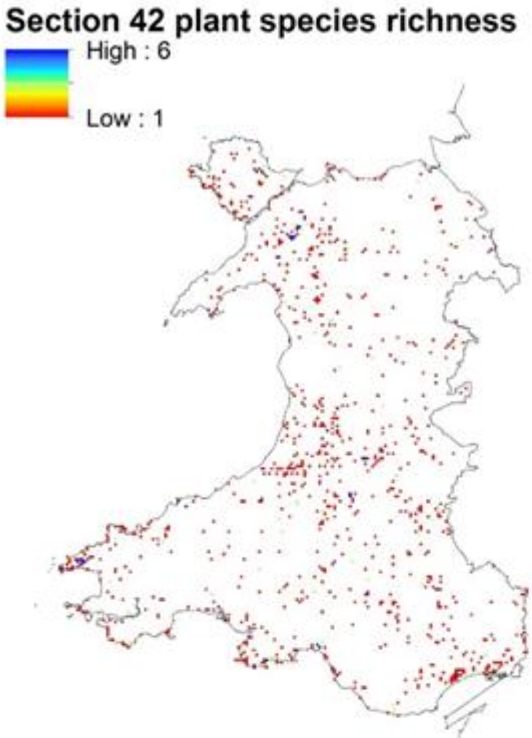

Figure 9.7.1.1 *Map showing the distribution of rare plant species (Section 42) across Wales*

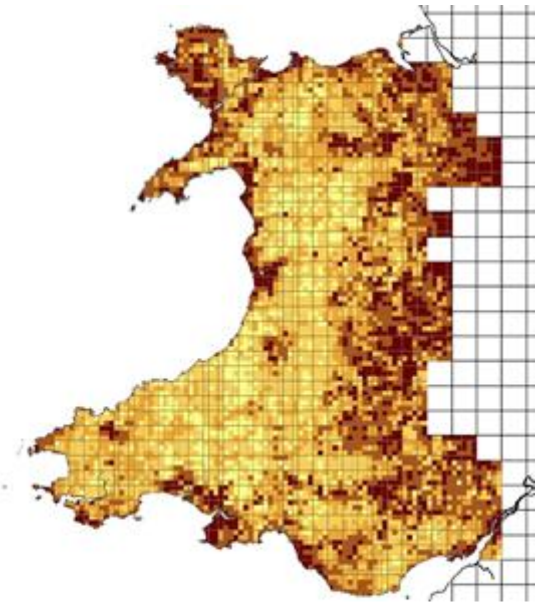

Figure 9.7.1.2 *Map showing the distribution of rare bird species (Section 42) across Wales*

Another potentially useful metric is the area of all SPAs SACs and SSSIs in a region. This was a metric used in HNV work carried out in Scotland, however, following meetings with stakeholders it was decided that, for this work, it may be more appropriate for the indicator of Type 3 HNV farmland to be based on species data. This data has been mapped for the case study areas to inform discussions.

9.8 Case study areas

For each of the case study areas, a set of maps was produced showing the different metrics with the potential to be used for mapping HNV farmland, produced from LCM2007 data. These maps were used to assess the usefulness of the different metrics as HNV indicators. Figures 9.8.1 and 9.8.2

below show example maps for the Conwy Valley case study area. Figure 9.8.1 is a map of land cover for the Conwy Valley from LCM2007, which was used to derive the metrics.

Type 1 HNV farmland can be represented by a map of all semi-natural land parcels (Figure 9.8.2a) or alternatively as the % SN habitat in each 1km^2 (Figure 9.8.2b). The advantage of the former is that it maintains the resolution of the input dataset so that small parcels of SN habitat are still visible. Conversely, the advantage of the % SN habitat is that it gives an aggregate value for each 1km^2 grid cell. This % SN habitat metric can be categorised, as in Figure 9.8.2b, or a threshold can be selected (e.g. 20 % SN habitat) below which the grid cell is not considered to contain HNV farmland.

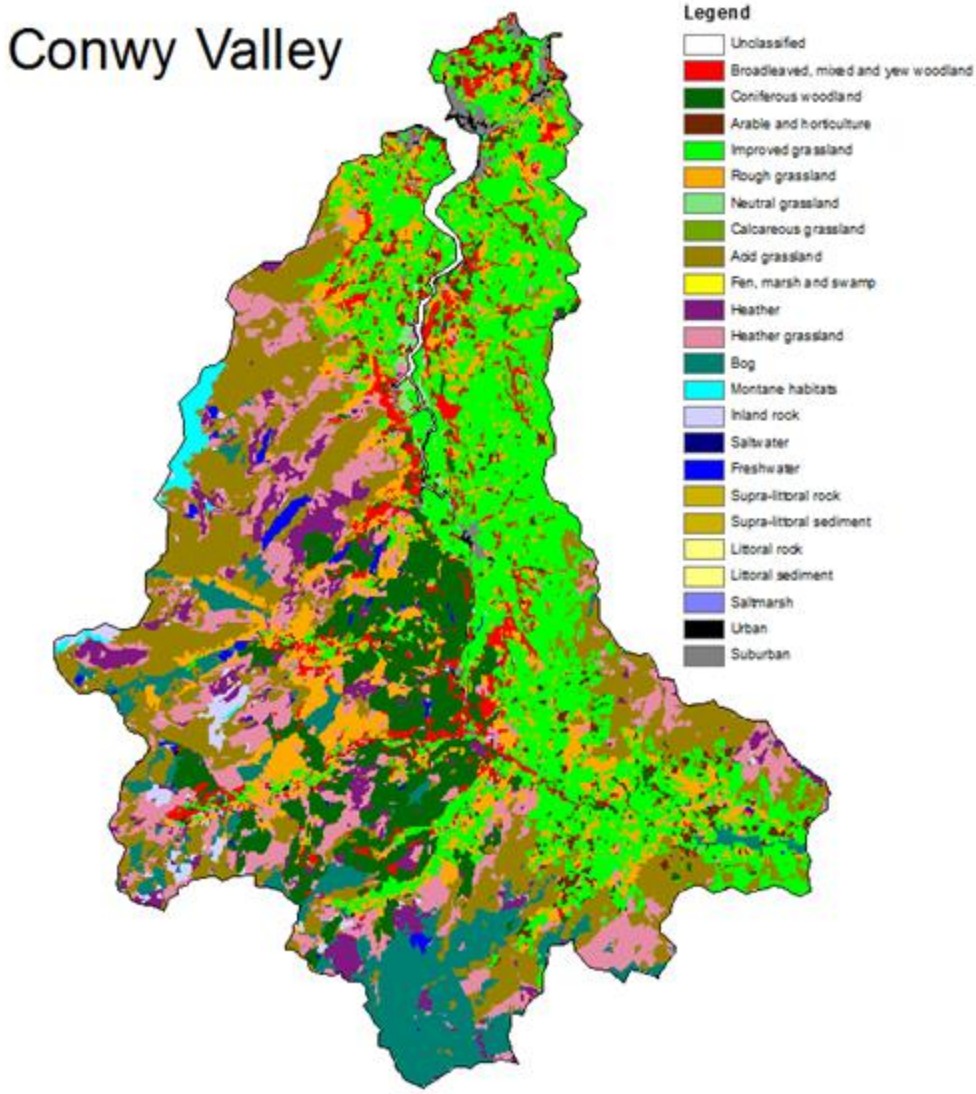

Figure 9.8.1 *Land cover map for the Conwy Valley from LCM2007.*

Figure 9.8.2c and 9.8.2d show the habitat count and habitat diversity (Shannon) in each 1km^2 grid cell for the Conwy Valley. The Shannon's Index of habitat diversity was thought to be the most useful metric for representing the mosaic of habitats representative of Type 2 HNV.

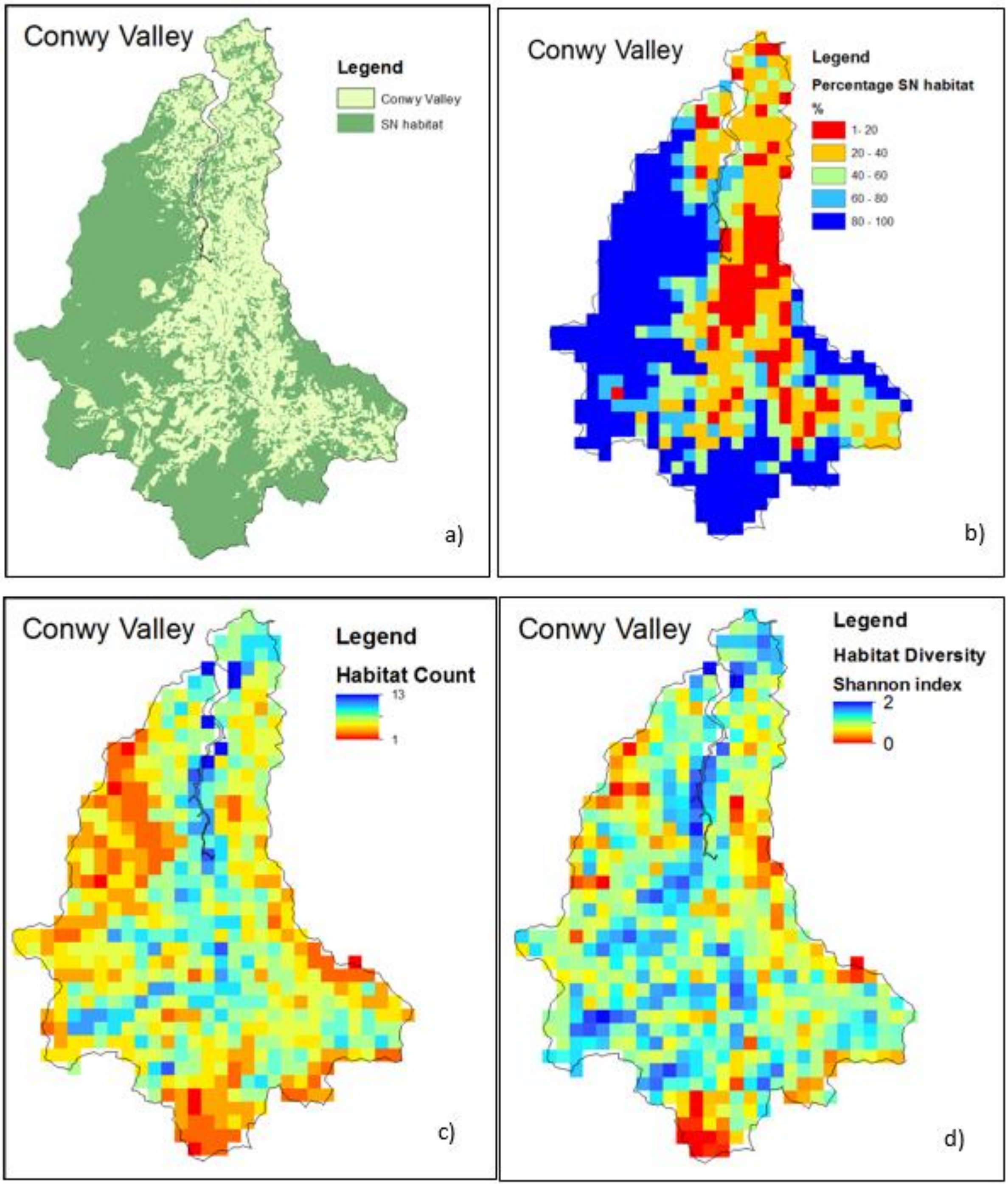

Figure 9.8.2 *Maps of potential HNV indicators for the Conwy Valley case study area, including: semi-natural habitat (a); % semi-natural habitat per 1km^2(b); habitat count (c); and habitat diversity – Shannon index (d).*

9.8.1 Preliminary HNV metrics

Based on the work undertaken so far the following metrics are proposed for HNV farmland:

Type 1:

- Option 1. Areas of all semi-natural land parcels (Figures 9.8.1.1a, 9.8.1.2a, 9.8.1.3a, 9.8.1.4a)
- Option 2. Use % semi-natural habitat and define a threshold – e.g. > 20 % - for HNV farmland

Type 2:

- Use upper quartile of habitat diversity (Shannon's Index) (Figures 9.8.1.1b, 9.8.1.2b, 9.8.1.3b, 9.8.1.4b)

- Incorporate connectivity into the metric (Figures 9.8.1.1f, 9.8.1.2a, 9.8.1.3a, 9.8.1.4a). The connectivity maps show the distribution of woodland connectivity over the case study areas. Grey areas have no connectivity because there are no areas of woodland. Blue cells have low connectivity and red cells have high connectivity, indicating woodland areas are highly connected. For each case study area most cells are blue, indicating that connectivity is low in most areas with a few hotspots of higher connectivity.
- Incorporate a metric of field boundary density as a surrogate of farmland intensity
- Incorporate species richness or presence/abundance of selected species, particularly species which are characteristic of a mosaic of habitats including low intensity farmland (not yet done).

Type 3:

- Could incorporate data on protected areas SPAs, SACs, SSSIs (Figures 9.8.1.1c, 9.8.1.2c, 9.8.1.3c, 9.8.1.4c) or might be used as a separate dataset to compare HNV metric to.
- Glastir target layers and protected zones could be used to identify HNV areas or as a dataset for comparison with an HNV metric (Figures 9.8.1.1d, 9.8.1.2d, 9.8.1.3d, 9.8.1.4d)
- Develop an indicator based on species data, particularly species which are rare or species for which a high proportion of European or world populations are found in the UK Figures 9.8.1.1e, 9.8.1.2e, 9.8.1.3e, 9.8.1.4e show data for Section 42 rare plants).

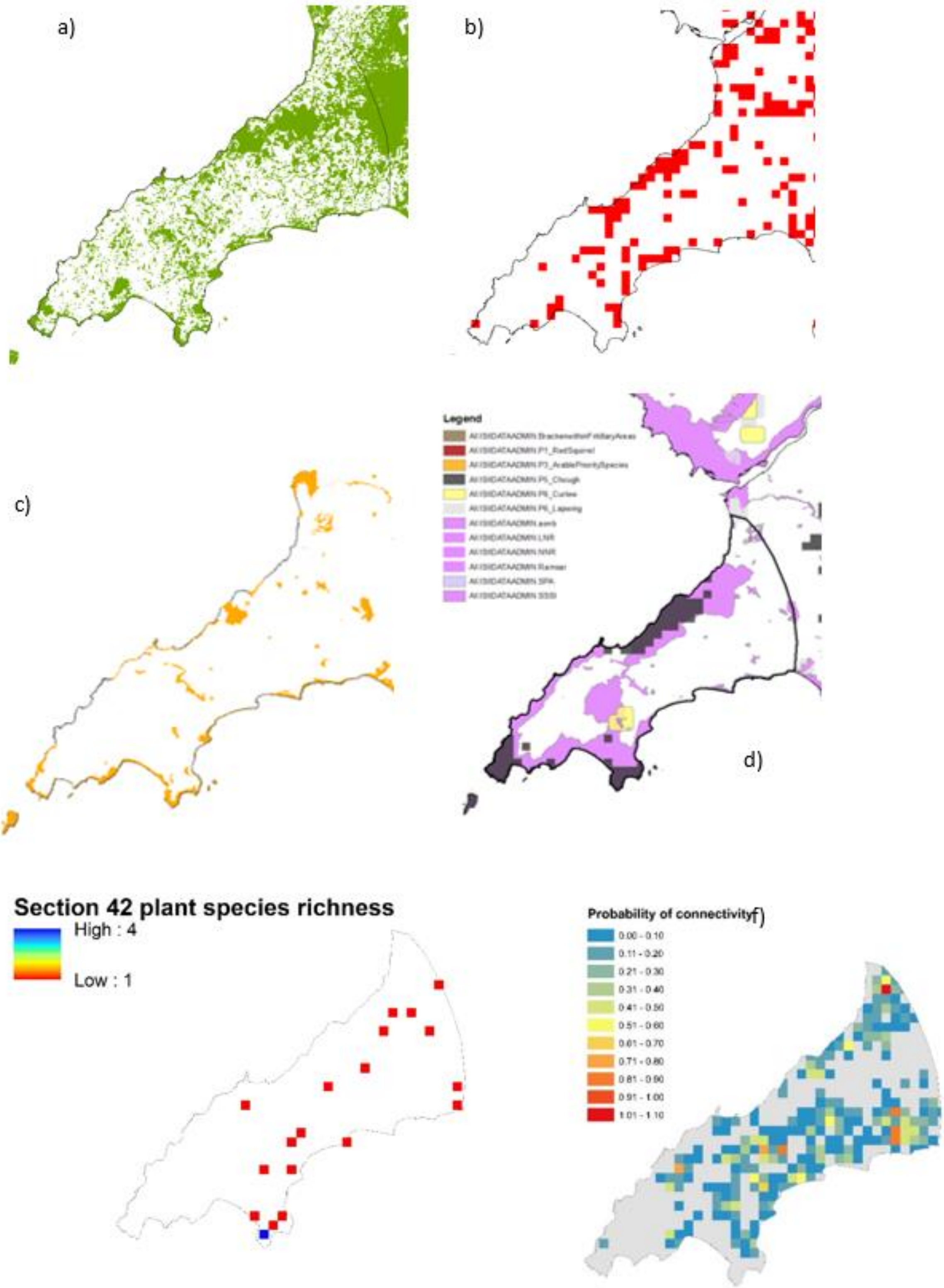

Figure 9.8.1.1 Maps of potential HNV indicators for Llyn Peninsula, including Type 1 – semi-natural habitat patches (a); Type 2 – Upper quartile of habitat diversity (Shannon Index; species data not yet incorporated) (b); Type 3 - SPAs, SACs and SSSIs (species data not yet included) as c; a map showing protected areas and protected zones (d), a map showing the distribution of rare plant species ((Section 42)(e), and Broadleaf woodland habitat connectivity metrics for each 1 km grid cell (f)

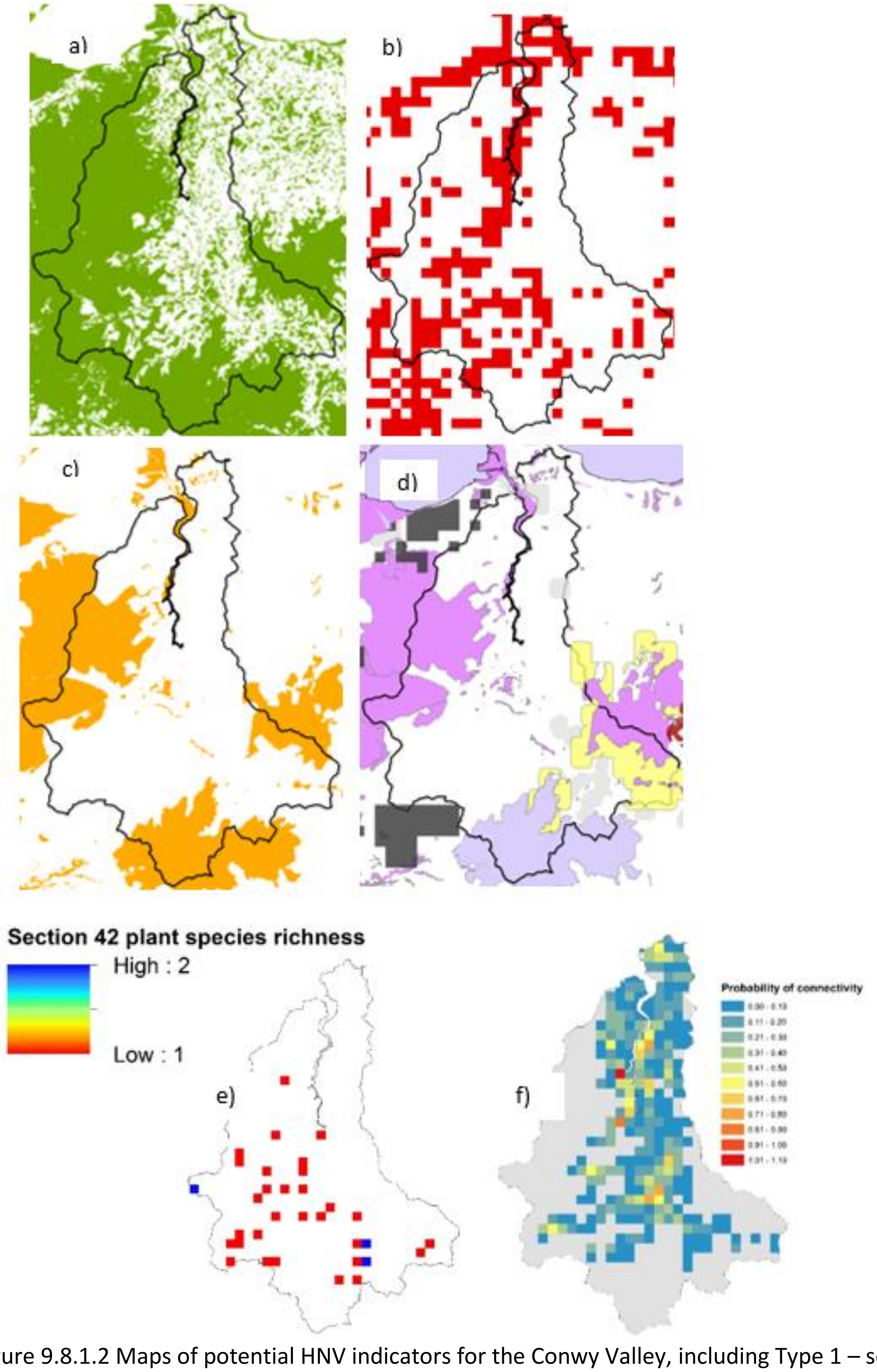

Figure 9.8.1.2 Maps of potential HNV indicators for the Conwy Valley, including Type 1 – semi-natural habitat patches (a); Type 2 – Upper quartile of habitat diversity (Shannon Index; species data not yet incorporated) (b); Type 3 - SPAs, SACs and SSSIs (species data not yet included); a map showing protected areas and protected zones (d) a map of rare plant species (Section 42) as e.) and Broadleaf woodland habitat connectivity metrics for each 1 km grid cell (f).

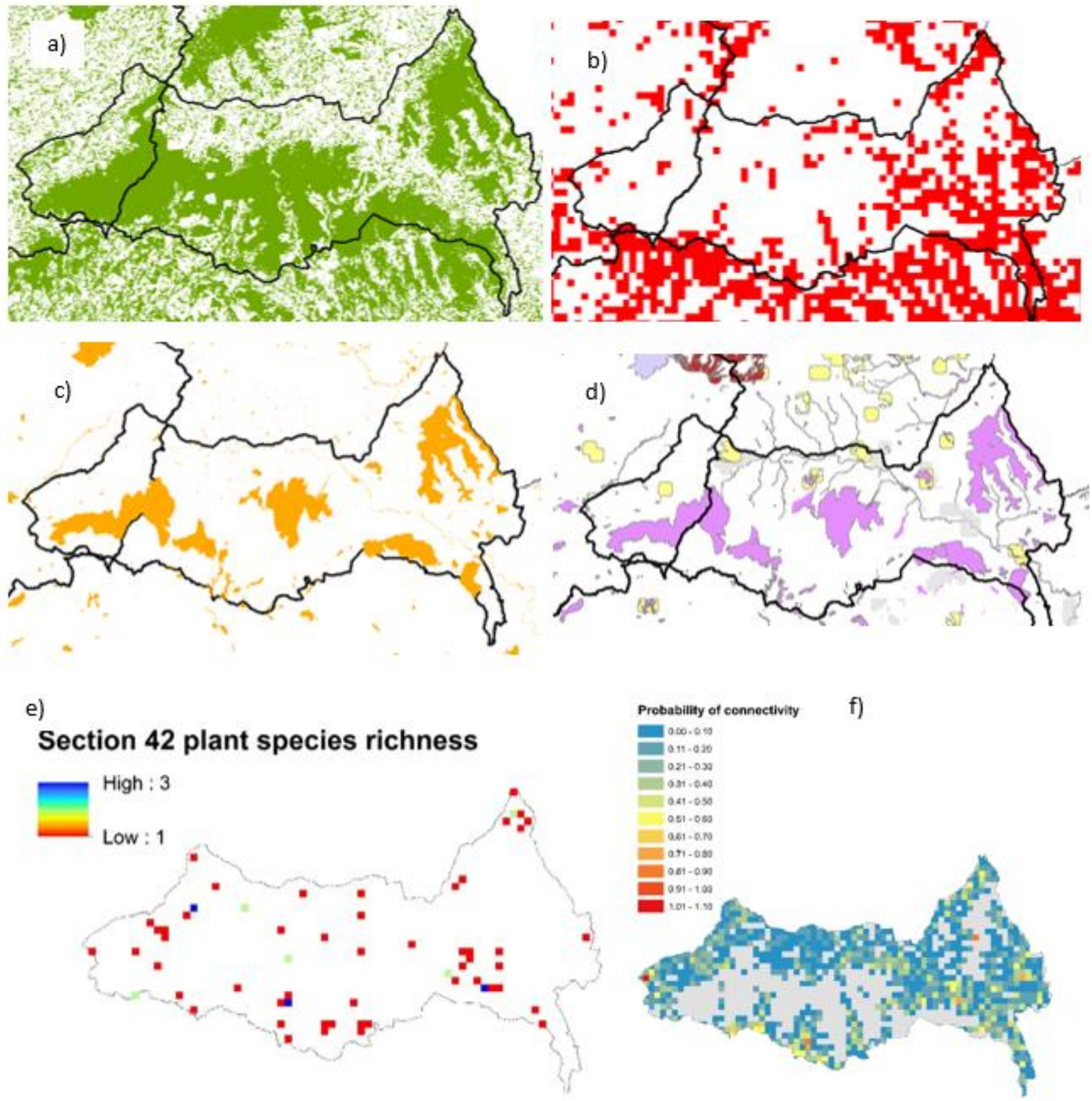

Figure 9.8.1.3 Maps of potential HNV indicators for the Brecon Beacons, including Type 1 – semi-natural habitat patches (a); Type 2 – Upper quartile of habitat diversity (Shannon Index; species data not yet incorporated) (b); Type 3 - SPAs, SACs and SSSIs (species data not yet included); a map showing protected areas and protected zones (d); a map of rare plant species (Section 42) in e.), and Broadleaf woodland habitat connectivity metrics for each 1 km grid cell (f).

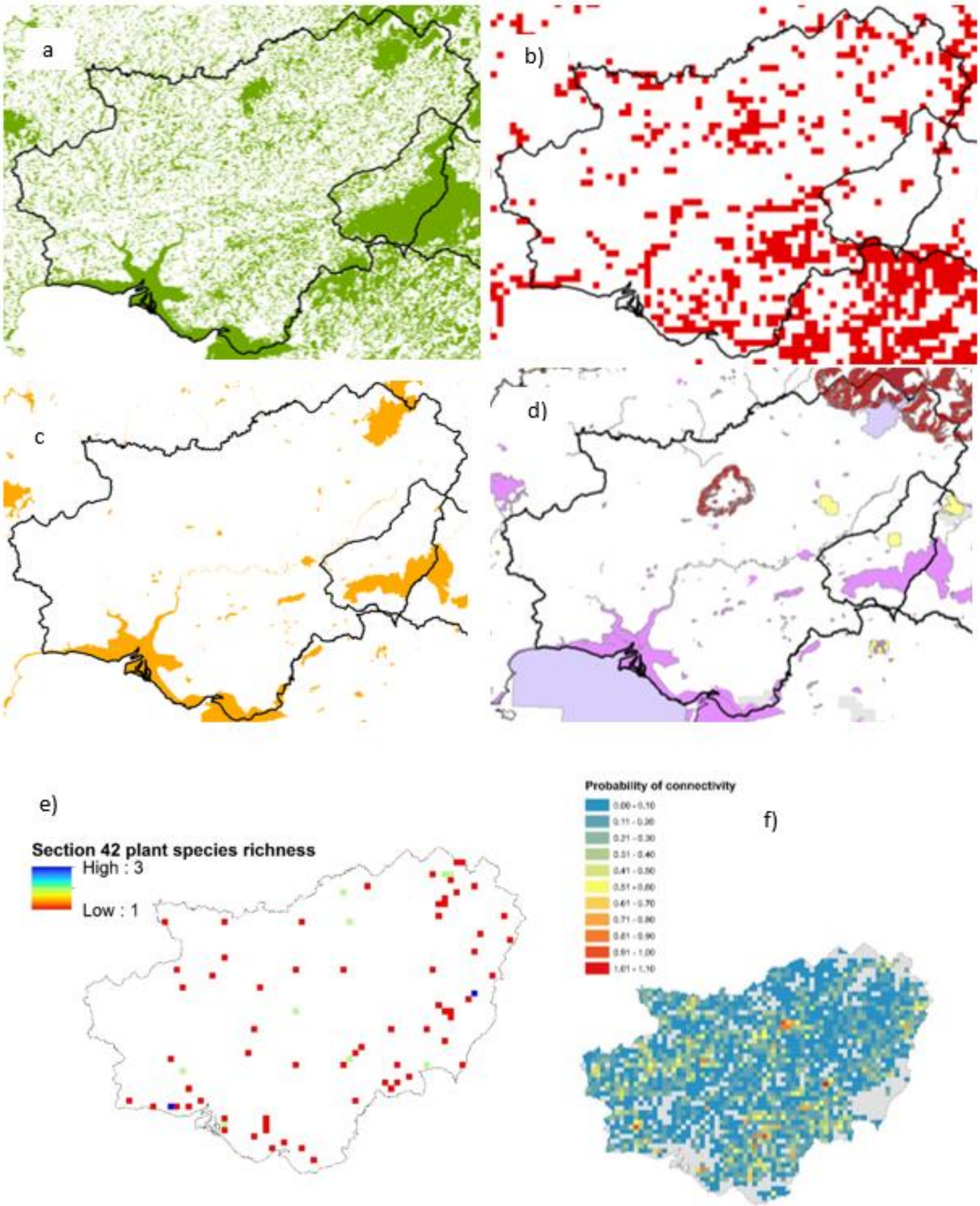

Figure 9.8.1.4 Maps of potential HNV indicators for Carmarthenshire, including Type 1 – semi-natural habitat patches (a); Type 2 – Upper quartile of habitat diversity (Shannon Index; species data not yet incorporated) (b); Type 3 - SPAs, SACs and SSSIs (species data not yet included); a map showing protected areas and protected zones (d) a map of rare plant species (Section 42) as e), and Broadleaf woodland habitat connectivity metrics for each 1 km grid cell (f)

9.8.2 Combining metrics and comparing case study areas

Figures *9.8.2.1*a to d show the relationships within the case study areas. For understanding how relationships vary between areas, plots were created using relative metrics within each area although they could also be calculated based on national relationships.

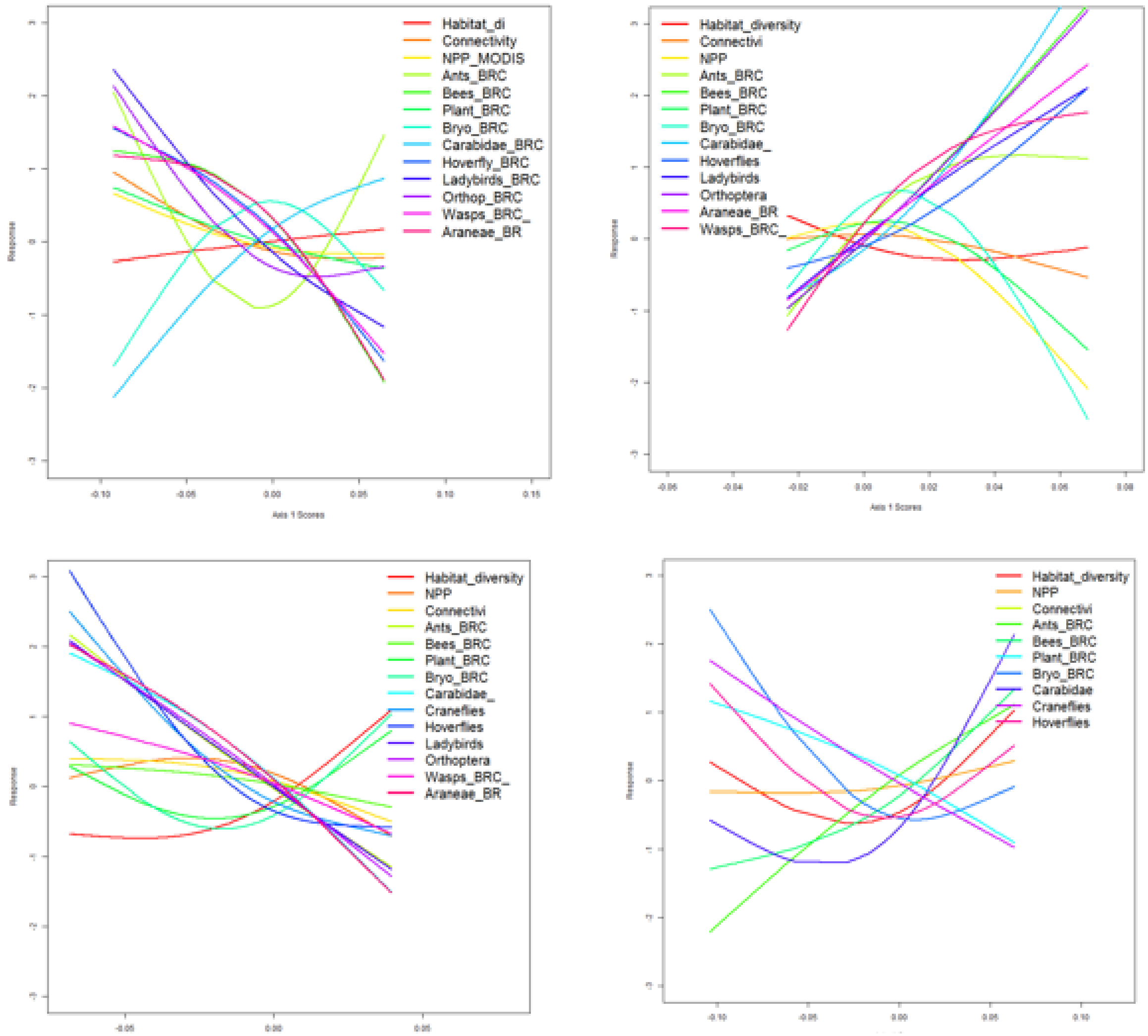

Figure 9.8.2.1a *(Top Left) relationships between diversity variables in Conwy*
Figure 9.8.2.1b *(Top Right) relationships between diversity variables in Carmarthen*
Figure 9.8.2.1c *(Bottom Left) relationships between diversity variables in Brecon*
Figure 9.8.2.1d *(Bottom Right) relationships between diversity variables in the Llyn Peninsula*

In most of the case study areas higher NPP was associated with lower diversity of all species types. The Llyn peninsula was slightly different as there was not a strong differential in NPP across the area. Habitat diversity was slightly more complex, in Conwy and Carmarthen higher habitat diversity tended to be associated with lower species diversity but in Brecon and the Llyn peninsula habitat diversity was positively associated with higher species diversity. There are also potential tradeoffs between different species metrics e.g. ants and bryophytes show different patterns in Conwy, In the Llyn peninsula plants and craneflies have opposing relationships to Bees and ants and in Brecon bryophytes and plants show curves in a different direction to most other forms of diversity. As mentioned above these are not final results, we do not yet have data at the most appropriate resolution and there needs to be more discussion of which would be the best metrics to use and whether they should be applied within an area (noted for particular important aspects of biodiversity and ecosystem services) or applied as more general metrics across Wales.

9.9 Soil HNV

The emphasis for HNV farmland is focused on above ground biodiversity, however, given the importance of the soil resource, and the potential links between above and below ground biodiversity it is of interest to explore the relationship between the soil resource and HNV areas. There is no accepted methodology for identifying HNV soil ecosystems, whilst a brief survey of the literature indicates that neither is there any agreed approach for identifying what might be considered rare or endangered soil ecosystems.

9.9.1 Why should we care about the soil resource in this way?

Historically, valuation of soils has been utilitarian, where by soils are valued by virtue of their use for agriculture and food production. However, soils fulfil a variety of often unseen functions of value both to mankind and the health of the earth system. In particular, the soil ecosystem provides an important habitat and gene pool. Historically this gene pool has provided us with many important organisms that have benefited mankind and yet we are aware of perhaps less than 1% of its diversity and function. Major advances were made last century with the extraction of antibiotics from soils (D'Costa et al., 2006) which are used widely in human health and agriculture. Health research continues to benefit from the extraction of organisms from soil, especially for drug delivery (Parkinson, 2011) and new antibiotics (Ling et al., 2015; Roberts, 2015). Moreover, soils provide a range of other functions that are valuable for maintaining the earth system which include, soil being the largest terrestrial store of carbon (Tipping, 2002), helping regulate climate; whilst moisture, texture, and soil structure control the partitioning of precipitation between infiltration and runoff at the land surface, and hence the regulation of surface water flows and flooding. Soil moisture also buffers climate extremes such as heat waves (Seneviratne et al., 2006). It is these climate extremes which are now seen as the most major threat to UK food security (HC 243, 2014). Furthermore, soils fulfil a range of other functions that we could not survive without including nutrient transformation and waste recycling etc.

9.9.2 Overview of the soil resources of Wales

The soils of Wales are mapped as part of the soil survey of England and Wales (Avery, 1980; Rudeforth et al., 1984). The national soil map for Wales is available at reconnaissance scale, 1:250,000, although there are some maps with greater detail (Reynolds et al., 2002). The soil survey of England and Wales (NATMAP) uses a hierarchical classification scheme that identifies 4 hierarchical levels, 11 Main Groups, 44 Groups, 125 Sub Groups and 747 Series. There is no entire coverage of Wales at the series level of classification, so the 1:250,000 scale map groups series into soil associations, for which 298 are recognised in England and Wales (Cranfield University, 2015), with 98 being mapped in Wales. Analysis using the dominant method assumes that each mapped association contains its dominant soil series, whereas analysis using the estimated method assumes that each association may contain all series found in that association, in standard proportions as distributed with the dataset. When aggregated up from association level, 9 of the 11 Main Groups are to be found in Wales (Table 9.9.2.1). Given the 98 associations, and based on the percentage of dominant soil series in the association, one can estimate that as many as 434 soil series may occur in Wales.

Eleven major soil groups are recognized in the soil survey of England and Wales, of those, nine are found in Wales (Table 9.9.2.1.). 3 major groups are dominant the *brown soils*, *podzolic soils* and *surface-water gley soils*. The brown soils tend to be well drained and have iron oxides bound to silicate clays giving them their characteristic brown colour. Podzols are leached acidic soils, whilst the surface water gleys are subject to periodic saturation. There is not a one-to-one translation of England and Wales soil types into the IUSS Working Groups, World Reference Base (2006) reference soil groups. Those that correspond, and are found in Wales, are shown in the fourth column of Table 9.9.2.1 Conversion to WRB is useful because it allows comparison at global scales. The final column in Table 9.9.2.1 shows the approximate % abundance for WRB reference soil groups globally. The three major groups, brown soils, podzolic and surface water gley, though common in Wales are less common globally, particularly the podzols (umbrisols) and surface water gleys (stagnosols) which are amongst the least common soils globally. Wales has a particularly high abundance of surface-water-gley soils (25%), whereas globally these represent ~1% of soils, and podzolic soils (33%) ~3% globally. This is important because these soils though common in Wales can still represent an important ecosystem globally and the processes that make the soils unique may well result in rare or unique soil ecosystems containing unusual organisms that may be of benefit to humanity.

Soils of Wales NATMAP (NSRI) 1:250,000					
Main Group	Area (ha)	Name of Main Group	WRB 2006 name	Abundance in Wales (%)	Abundance Globally (%)
1	0	Terrestrial raw soils		0.00	
2	3846	Raw gley soils	Fluvisol	0.19	2
3	48797	Lithomorphic Soils	Leptosol / Arenosol / Histosol	2.36	11 / 6 / 2
4	2652	Pelosols	Luvisol	0.13	4
5	651862	Brown soils	Cambisols / Luvisol / Arenosol	31.55	10 / 4 / 6
6	681136	Podzolic soils	Podzolic / Umbrisol	32.97	3 / 1
7	526706	Surface-water gley soils	Stagnosol	25.50	1
8	68275	Ground-water gley soils	Gleysol	3.30	5
9	12707	Man made soils	Regosol	0.62	2
10	69867	Peat soils	Histosol	3.38	2
11	0	Compost-deepened man-modified soils		0.00	
	2065848	Soil total		100	
	10990.29	Other, lakes etc			
	2076838	Wales terrestrial area			

Table 9.9.2.1 Area of soil Main Groups determined based on the dominant soil type in each association. Natmap (NSRI, 2001). The dominant soils in Wales are the brown soils, podzolic and surface water gleys.

9.9.3 Soil Abundance

Abundance: A number of attempts have been made to assess soil pedodiversity or abundance (Ibanez, 1995; Amundson et al., 2003; Nikitin et al., 2007). This is not trivial given that most countries use different soil classifications, exemplified by the fact that England and Wales differ from Scotland. Attempts to unify classifications into a single typology is attempted through the World Reference Base (2006) and soils have been analysed at European (Ibanez, 2013) and global (Minasny et al., 2010) scales using the WRB database. No agreed classification of soil abundance exists, so a number of workers tend to follow the criteria proposed by Amundson (2003) who analysed the USA using the STATSGO database, a similar 1:250,000 scale reconnaissance soils map as that available for Wales. The following criteria were proposed:

a) rare soils—less than 1,000 ha total area in US,
b) unique soils (for example, "endemic")—exist only in one state, and
c) rare-unique soils—occur only in one state, total area less than 10,000 ha.
d) endangered soils: rare or rare-unique soil series that have lost more than 50% of their area to various land disturbances

In Scotland work has been undertaken to identify, soils of national conservation importance (Towers et al., 2005; 2008); soils are assessed based on conservation and functional importance. Abundance was one of the criteria used (Towers et al., 2005), and they tested 3 methods of assessing abundance. The first of their methods wasn't applicable to Wales so we modified the other two for use with the Wales data.

b) Dominant soil sub-group method Wales: Each soil association map unit is allocated to the predominant Major Soil Sub-Group within it. The area for each soil subgroup is summed and the hectares of soil estimated and compared to 1 million ha (Equ 1).

c) Soil series estimated sub-group summation method Wales: The percentage cover of each soil series sub-group, in all associations, is estimated based on the Soils Guide (Cranfield University, 2015). The area for each soil subgroup is summed and the hectares of soil estimated and compared to 1 million ha (Equ 1).

$$ha\ of\ soil\ in\ 1\ million\ ha = \frac{Soil\ area\ (ha) \times 1{,}000{,}000\ ha}{Total\ area\ of\ soil\ in\ Wales\ (=2{,}065{,}848\ ha)} \qquad \text{(Equ 1)}$$

A substantial body of work is available from ecology that is used to define rare and endangered species, which are compiled in the IUCN Red List (IUCN, 2001; Rodrigues et al., 2006). We use a synthesis of the red list approach (IUCN, 2001) and soil pedodiversity approaches (Amundson et al., 2003) to classify the soils of Wales. The soils were analysed based on the area occupied by a soil sub-group in 1 million ha of Wales according to the following criteria:

A) **Abundance: Area of Occupancy** (ha) = area covered by soil subgroup / total area of political boundary >1 million

<1000 ha per 1000000 ha = 0.001 = <0.1%	Rare
<10,000 ha per 1000000 ha = 0.01 = <1%	Occasional
<50,000 ha per 1000000 ha = 0.05 = <5%	Frequent
<100,000 ha per 1000000 ha = 0.1 = <10%	Common
>100,000 ha per 1000000 ha = >0.1 = >10%	Abundant

B) **Extent: of occurrence** (ha) = Perimeter length of a polygon around all the exposures / outcrops

C) **Uniqueness: Number of locations** = 1 million ha from the political boundary of interest.

1 location in 1,000,000 ha =	Unique
<10 locations in 1 million ha =	Occasional
<50 locations in 1 million ha =	Frequent
<100 locations in 1 million ha =	Common
>100 locations in 1,000,000 =	Abundant

Results using the dominant soil Sub-Group method (a) are presented in Table 9.9.3.1. Thirty four soil sub-groups are found in dominant amounts, occurring in 94 soil associations. Of these soil sub groups 4 would be classified as rare occupying less than 1000 ha, and 18 would be occasional, occupying less than 10,000 ha. Of the rare soils, 3 are unique with only one exposure at this scale and are thus of limited extent. These rare soils occur due to a confluence of unusual processes. For example, the Cors Erddreiniog fens on Anglesey are organic soils with alkaline water draining into them, organic soils normally form in acid environments. We don't know if the soil organisms associated with these ecosystems are unusual compared to other soils but the technology is developing in terms of genetic profiling that will enable us to determine whether they are or not (see Section 7.7.9), however, the Fens support a wide range of rare above ground biodiversity. Research priorities need to focus on understanding soil change on the whole (Robinson, 2015) which will then allow us to put data from rare or unique environments into perspective.

Soils of Wales NATMAP (NSRI) 1:250,000									
Subgroup	Area (ha)	Name of subgroup	Abundance %	Abundance	Criteria	Cumulative abundance %	Extent (proportional to greatest extent)	Number of occurances	Percentage of extent occupied by subgroup (area/ extent)*100
541	545751	Typical brown earths	26.418	Abundant	>=10%	100.000			
611	453114	Typical brown podzolic soils	21.934	Abundant	>=10%	73.582			
713	308997	Cambic stagnogley soils	14.957	Abundant	>=10%	51.649			
654	179201	Ferric stagnopodzols	8.674	Common	<10% >=5%	36.691			
721	164033	Cambic stagnohumic gley soils	7.940	Common	<10% >=5%	28.017			
1013	67543	Raw oligo-amorphous peat soils	3.270	Frequent	<5% >=1%	20.077			
571	42767	Typical argillic brown earths	2.070	Frequent	<5% >=1%	16.807			
811	40673	Typical alluvial gley soils	1.969	Frequent	<5% >=1%	14.737			
561	37925	Typical brown alluvial soils	1.836	Frequent	<5% >=1%	12.768			
711	36216	Typical stagnogley soils	1.753	Frequent	<5% >=1%	10.932			
311	31807	Humic rankers	1.540	Frequent	<5% >=1%	9.179			
612	26830	Humic brown podzolic soils	1.299	Frequent	<5% >=1%	7.640			
712	17459	Pelo-stagnogley soils	0.845	Occasional	<1% >=0.1%	6.341	0.525	50	1.44
631	14899	Humo-ferric podzols	0.721	Occasional	<1% >=0.1%	5.496	1.000	45	0.64
572	13444	Stagnogleyic argillic brown earths	0.651	Occasional	<1% >=0.1%	4.774	0.387	26	1.50
361	13142	Typical sand-pararendzinas	0.636	Occasional	<1% >=0.1%	4.124	0.873	49	0.65
962	10474	Permeable, seasonally wet raw made ground soils	0.507	Occasional	<1% >=0.1%	3.488	0.316	44	1.44
814	9828	Pelo-calcareous alluvial gley soils	0.476	Occasional	<1% >=0.1%	2.981	0.012	16	36.05
651	6950	Ironpan stagnopodzols	0.336	Occasional	<1% >=0.1%	2.505	0.035	14	8.64
551	6898	Typical brown sands	0.334	Occasional	<1% >=0.1%	2.168	0.490	14	0.61
813	6837	Pelo-alluvial gley soils	0.331	Occasional	<1% >=0.1%	1.835	0.439	30	0.67
812	4925	Calcareous alluvial gley soils	0.238	Occasional	<1% >=0.1%	1.504	0.005	6	42.36
313	3848	Brown rankers	0.186	Occasional	<1% >=0.1%	1.265	0.722	25	0.23
220	3846	Unripened gley soils	0.186	Occasional	<1% >=0.1%	1.079	0.327	60	0.51
821	3512	Typical sandy gley soils	0.170	Occasional	<1% >=0.1%	0.893	0.180	13	0.84
543	2795	Gleyic brown earths	0.135	Occasional	<1% >=0.1%	0.723	0.002	2	52.72
431	2652	Typical argillic pelosols	0.128	Occasional	<1% >=0.1%	0.587	0.010	5	11.51
871	2294	Typical humic gley soils	0.111	Occasional	<1% >=0.1%	0.459	0.022	10	4.49
542	2282	Stagnogleyic brown earths	0.110	Occasional	<1% >=0.1%	0.348	0.056	8	1.77
924	2233	well aerated raw made ground soils	0.108	Occasional	<1% >=0.1%	0.238	0.065	10	1.50
1024	1659	Earthy eutro-amorphous peat soils	0.080	Rare	<0.1%	0.129	0.163	13	0.44
1022	665	Earthy eu-fibrous peat soils	0.032	Rare	<0.1%	0.049	0.000	1	72.55
831	207	Typical cambic gley soils	0.010	Rare	<0.1%	0.017	0.000	1	66.97
652	144	Humus-ironpan stagnopodzols	0.007	Rare	<0.1%	0.007	0.000	2	23.34
Total	2065848		100						

Table 9.9.3.1 *Soil metrics determined from Natmap (NSRI, 2001) data according to the rarity, extent and uniqueness outlines above. Where "extent" is calculated as the minimum bounding convex hull polygon.*

The dominant method used to identify the soils in Table 9.9.3.1 can be compared with the estimated method. Figure 9.9.3.1a shows the exposures of rare soils using the dominant method (a) and estimated method (b). Using the estimated method there is no guarantee that the mapped association will actually contain a soil series of interest. The number of associations that might include rare soils is greater and when plotted appears to cover a greater area simply because the association is plotted, not the exposure of the soil series that might be contained within it (Figure 9.9.3.1b). The rare soils tend to occur in North and South Wales, with little in mid Wales and are often close to coastal areas or water courses.

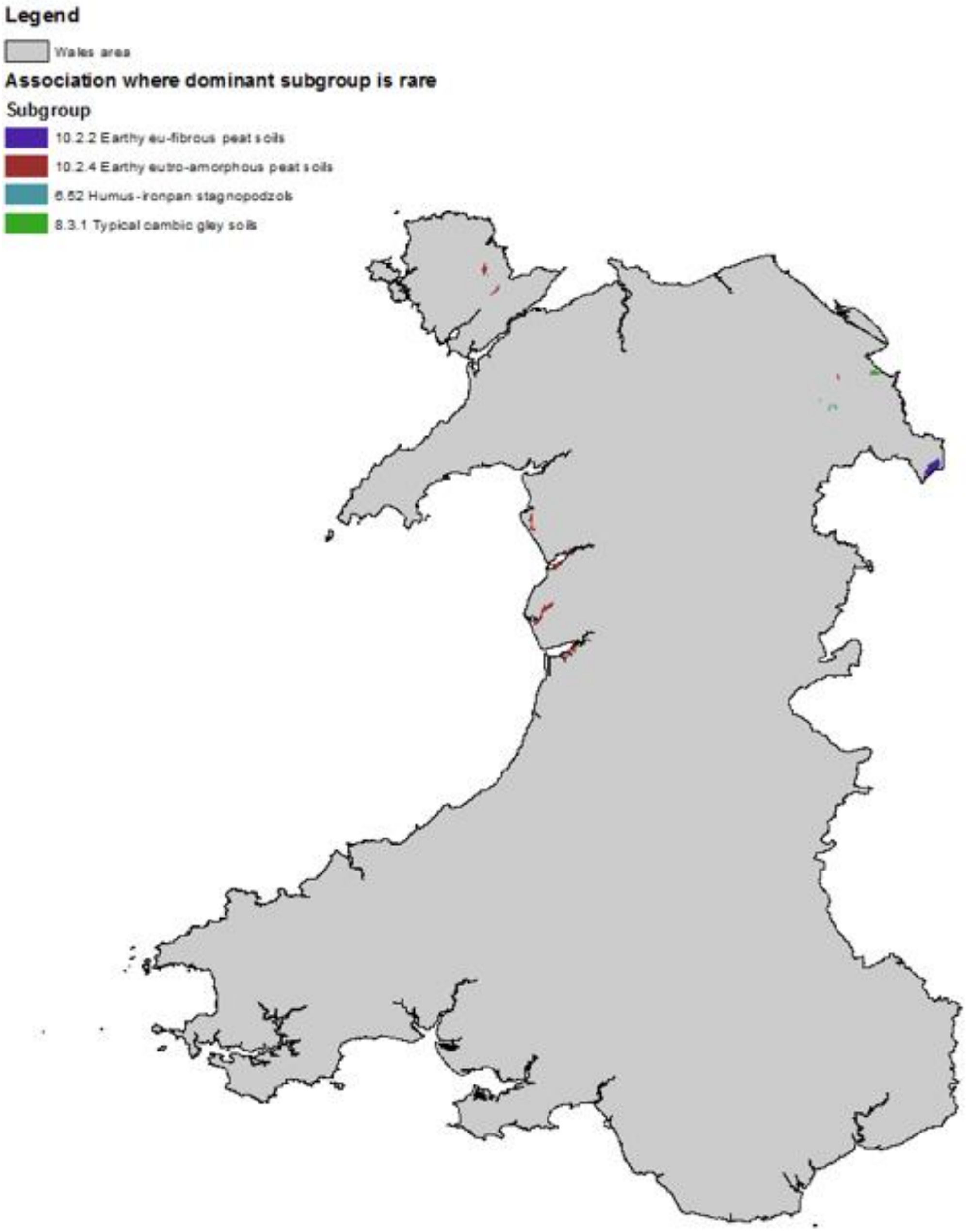

Figure 9.9.3.1a. *Associations which probably contain rare soils (<0.1%) mapped according to the dominant soil sub-group method. The dominant sub group assumes that each soil association (as mapped by NSRI) is made up of the dominant series for that association; this soil may make up 100% of the relevant association, but where the percentage is lower, there is a possibility that the association mapped does not contain the soil of interest.*

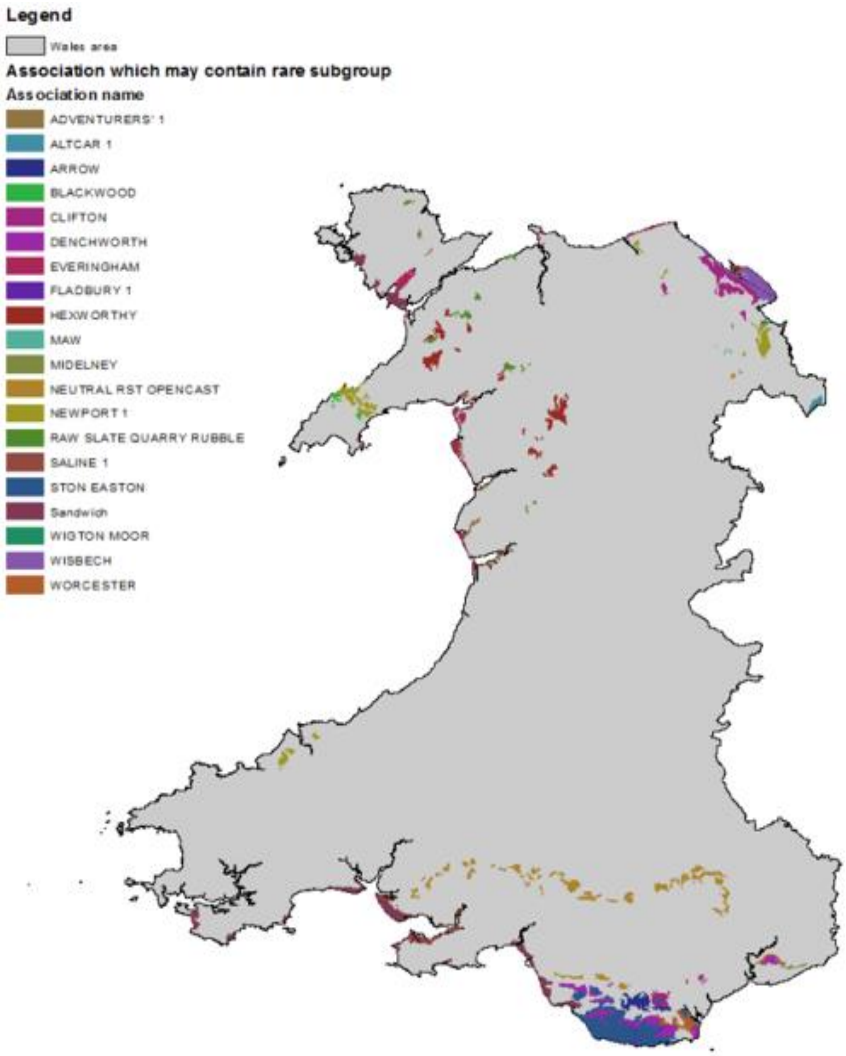

Figure 9.9.3.1b *Associations which may contain rare soils (<0.1%) mapped according to the estimated soil series sub-group method. The estimated approach assumes that each soil association (as mapped by NSRI) contains all soil series which may be found in that association, in proportions consistent with the average for that association. This approach identifies a greater number of soils which may be present, although there is no guarantee that the mapped association will actually contain the soil series of interest.*

Similarly plots can be created for the occasional soils using the dominant (Figure 9.9.3.2a) and estimated methods (Figure 9.9.3.2b). The estimated method is informative showing the existence of complexes on the Llyn Peninsula, Anglesey, the South Wales Valleys, the Gower Peninsula and the Dee valley in North Wales. These areas are consistent with more complex geology, providing a diversity of parent materials that is perhaps reflected by the soils. This leads to the question as to whether these areas are also associated with higher above ground biodiversity.

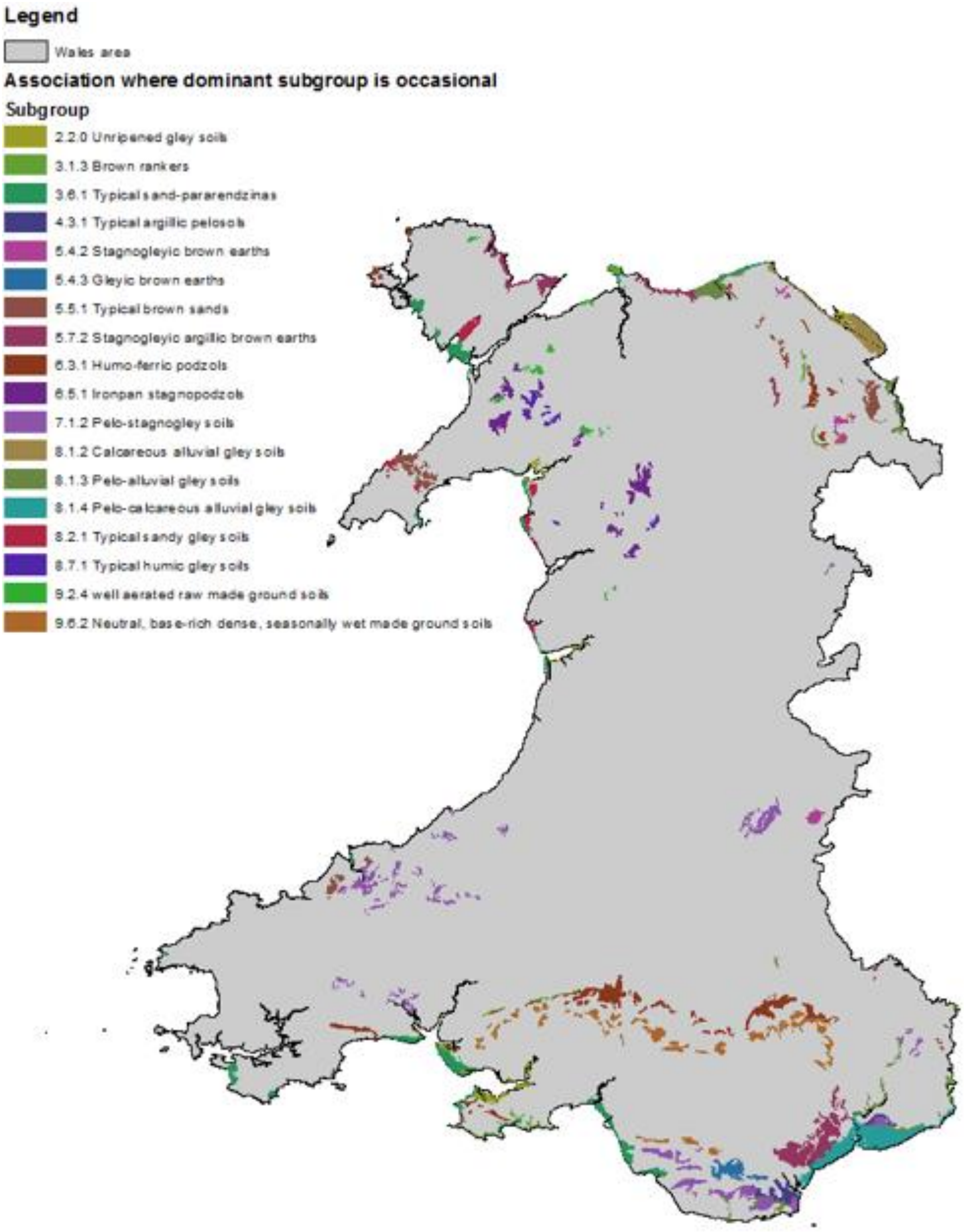

Figure 9.9.3.2a *Associations which probably contain occasional soils (<1%) mapped according to the dominant soil sub-group method. The dominant sub group assumes that each soil association (as mapped by NSRI) is made up of the dominant series for that association; this soil may make up 100% of the relevant association, but where the percentage is lower, there is a possibility that the association mapped does not contain the soil of interest.*

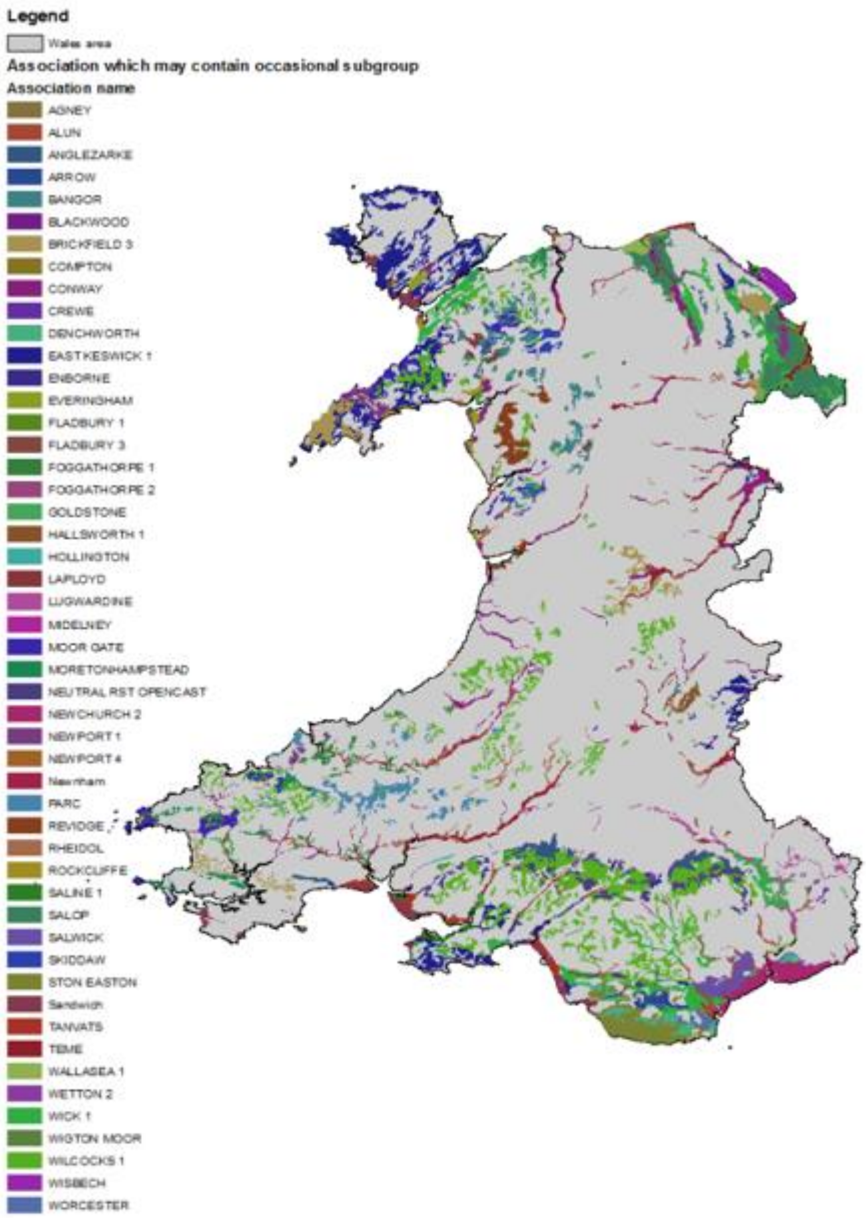

Figure 9.9.3.2b *Associations which may contain occasional soils (<1%) mapped according to the estimated soil series sub-group method. The estimated approach assumes that each soil association (as mapped by NSRI) contains all soil series which may be found in that association, in proportions consistent with the average for that association. This approach identifies a greater number of soils which may be present, although there is no guarantee that the mapped association will actually contain the soil series of interest.*

9.9.4 Relationships between soil, land cover and SSSI's

Many of the rare (51%) and occasional soils (29%) can be found within Sites on Special Scientific Interest in Wales. There are 1061 SSSIs in Wales, covering 261849 ha or 13% of the Welsh land area. Rare and occasional soils make up 7% of this area. Of the rare soils, 54% of rare peat soils (including 95% of earthy eu-fibrous peat soils) and 72% of humus-ironpan stagnopodzols are found within SSSI areas. Pelo-calcareous alluvial gley soils are the most common occasional soils within SSSIs making up 2.3% of the total SSSI area. Land cover in SSSI areas can be quite diverse, with areas of rare and occasional soils in SSSI areas associated with slightly more land cover richness and diversity than other SSSI.

In terms of diversity, a range of diversity metrics have been used to calculate above and below ground diversity. Using the Land Utilisation and Capability Indicator (LUCI) tool (Jackson et al., 2014) at 1km squares across Wales, four options of diversity were determined including richness, mean patch size, Shannon diversity index and Simpson diversity index (as used above). These metrics are commonly used in above ground biodiversity studies, and are increasingly receiving attention in soil pedodiversity (Minasny et al., 2010). All four diversity indices show very little relationship between current land cover and soil diversity across Wales, possibly due to extensive modification of climax vegetation in the area. Areas underlain by rare and occasional soils, using both dominant (Figures 9.9.4.1a-d) and estimated (Figures 9.9.4.2a-d) methods, also had little relationship with above ground diversity with a wide range of diversity values for each of the four metrics observed. Despite this, some of the areas in which rare and occasional soils are present also have some of the highest diversity in land cover, particularly in north-western areas (dominant method) and areas in the north-east and south (estimated method).

Statistical analysis comparing average habitat metric values for all of Wales and those over rare and occasional soils indicate that above ground diversity is slightly higher in these areas (Table 9.9.4.1). Although the differences do not appear large, three of the four metrics were statistically significantly at the 5% level (Table 9.4.4.2). Rare and occasional soils were also analysed separately. Habitat metric values in areas of occasional soils are greater than average Welsh values, and significant at the 5% level. Areas of rare soils also tend to have greater diversity (compared to the Welsh average and areas of occasional soils). However, due to the smaller sample size (50 cells) these results were not statistically significant.

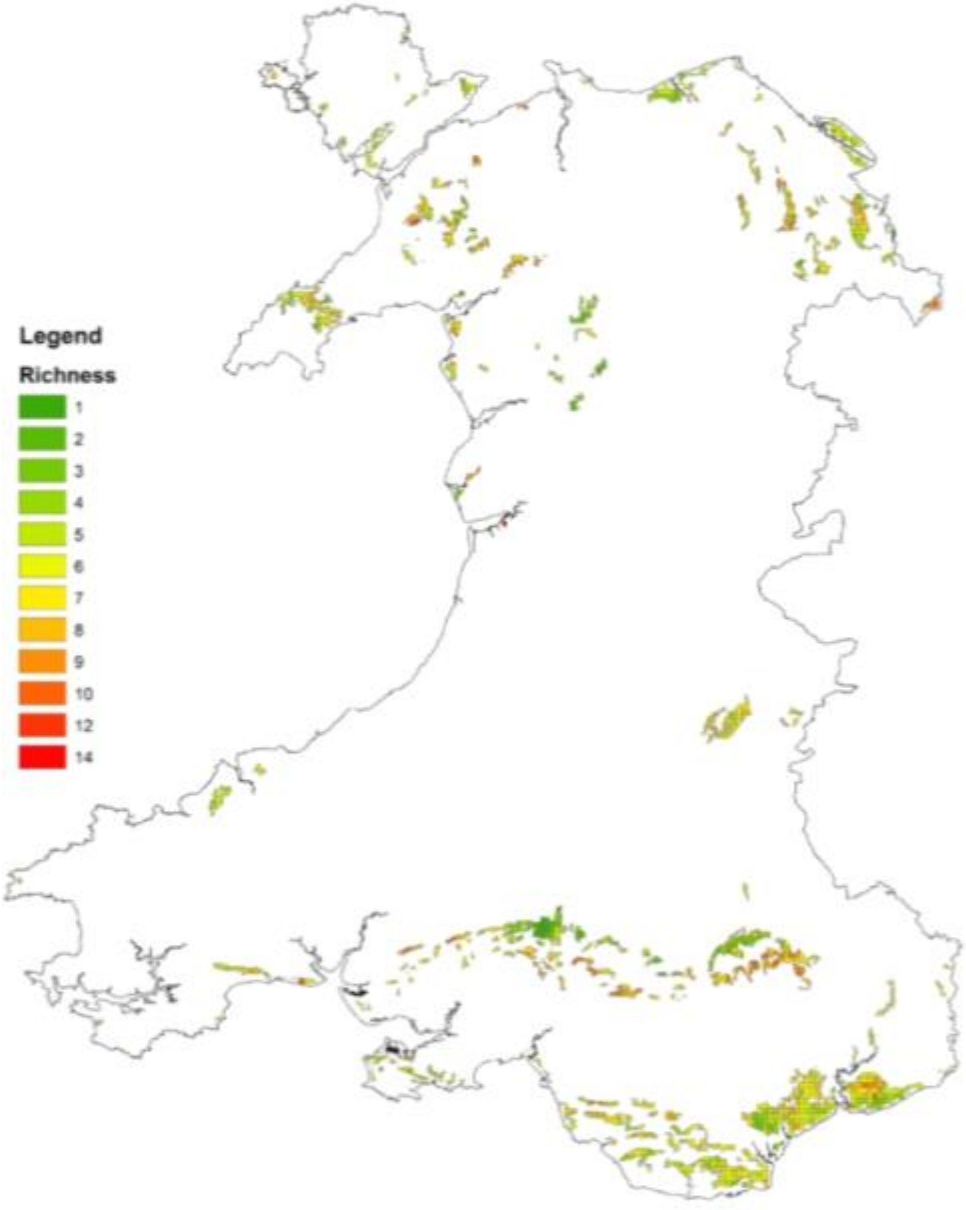

Figure 9.9.4.1a. *Land cover richness in areas of rare and occasional soils (dominant method). Red areas identify rare or occasional soils with high levels of above ground richness, determined by the number of different land covers within each 1km^2 square. These areas are found largely in north-western regions, and to a lesser extent in the south. The highest richness is found in a single square located near the River Dyfi, north of Aberystwyth.*

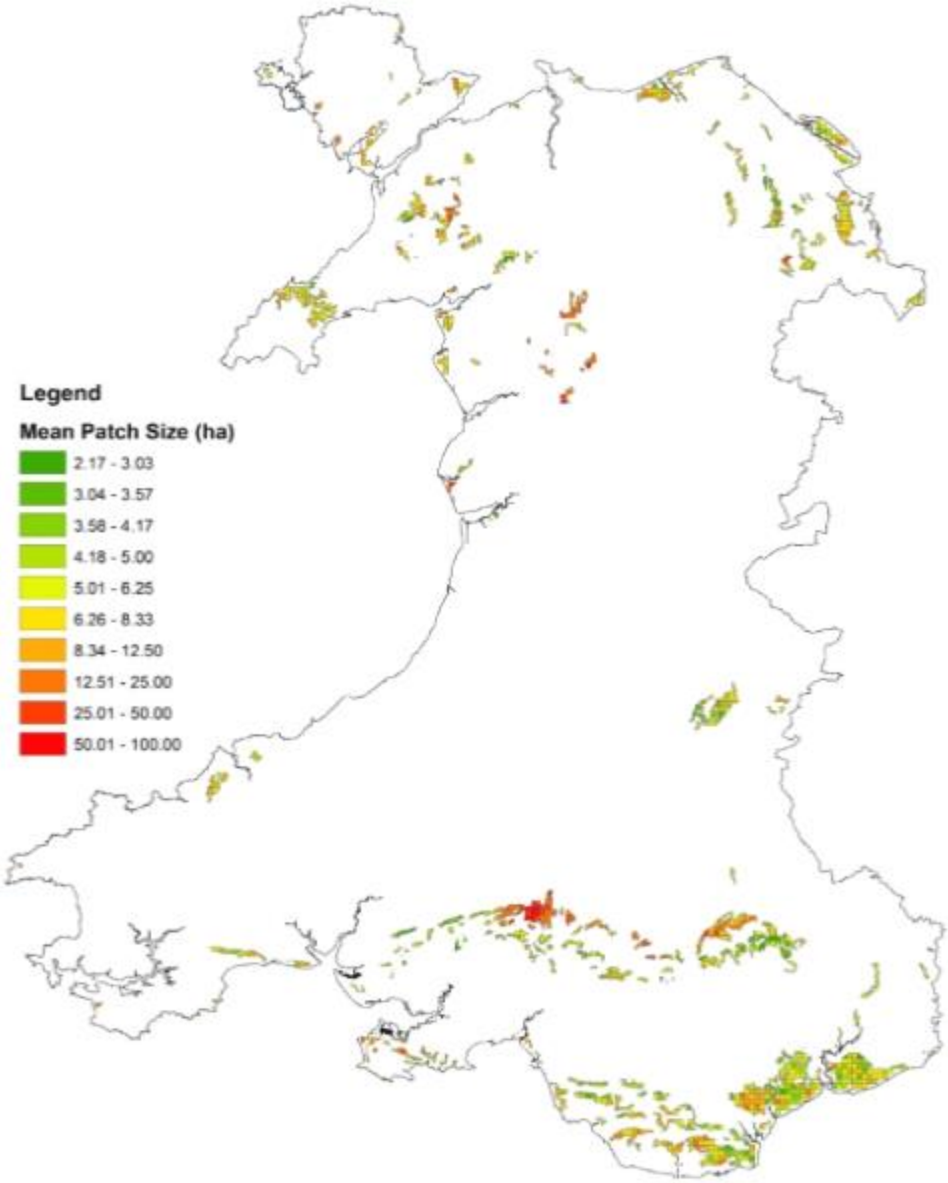

Figure 9.9.4.1b *Land cover mean patch size (ha) in areas of rare and occasional soils (dominant method). Red areas identify rare or occasional soils with larger mean patch size. These areas tend to be in the uplands, in the north around Snowdonia and in the South around Brecon and the Black Mountains. Areas with lower richness generally have higher mean patch size.*

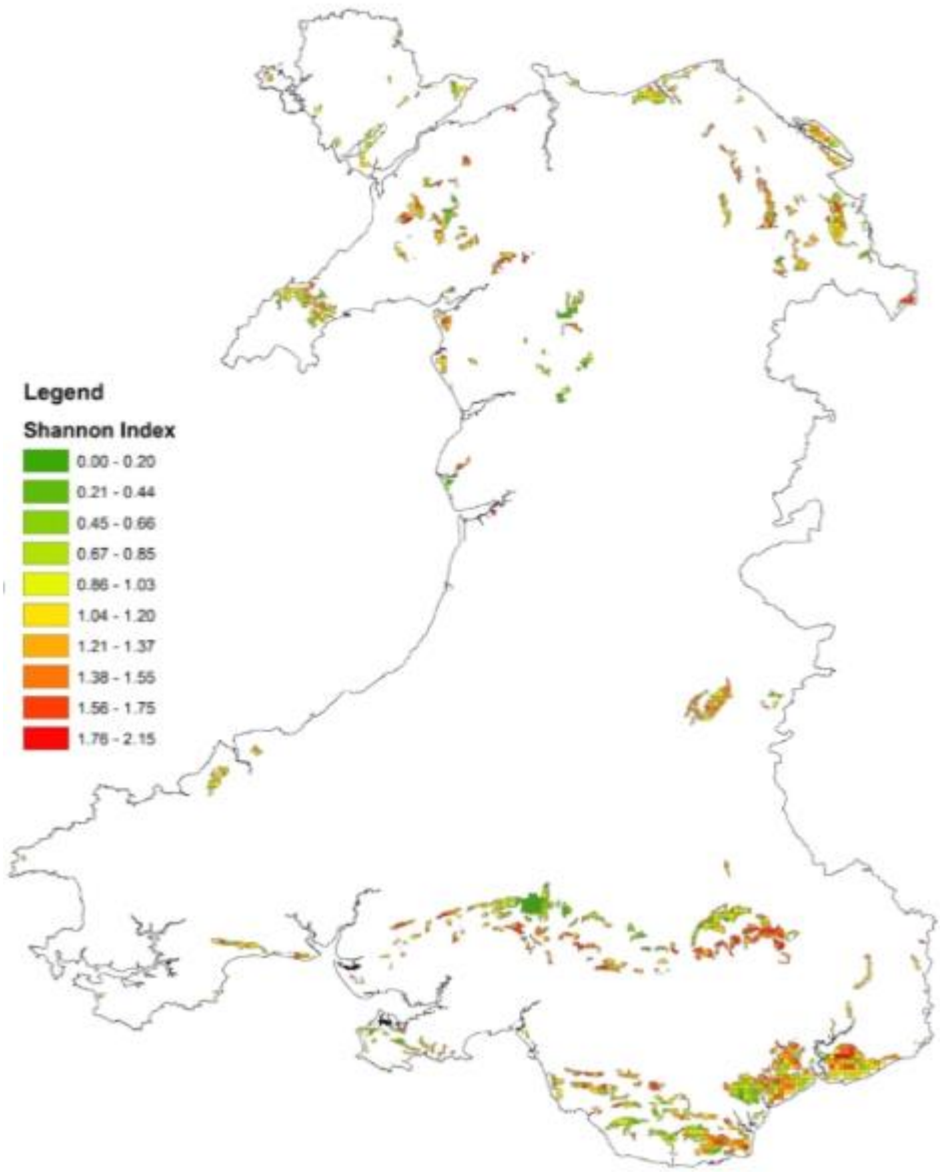

Figure 9.9.4.1c. *Land cover Shannon Index in areas of rare and occasional soils (dominant method). Larger values indicate higher diversity, with greater weight to areas with higher richness, regardless of whether one land cover is dominant. Red areas identify rare or occasional soils with high levels of above ground biodiversity. These occur throughout Wales, but more widely in the uplands, in the north around Snowdonia and in the South around Brecon and the Black Mountains, as well as the area around Newport.*

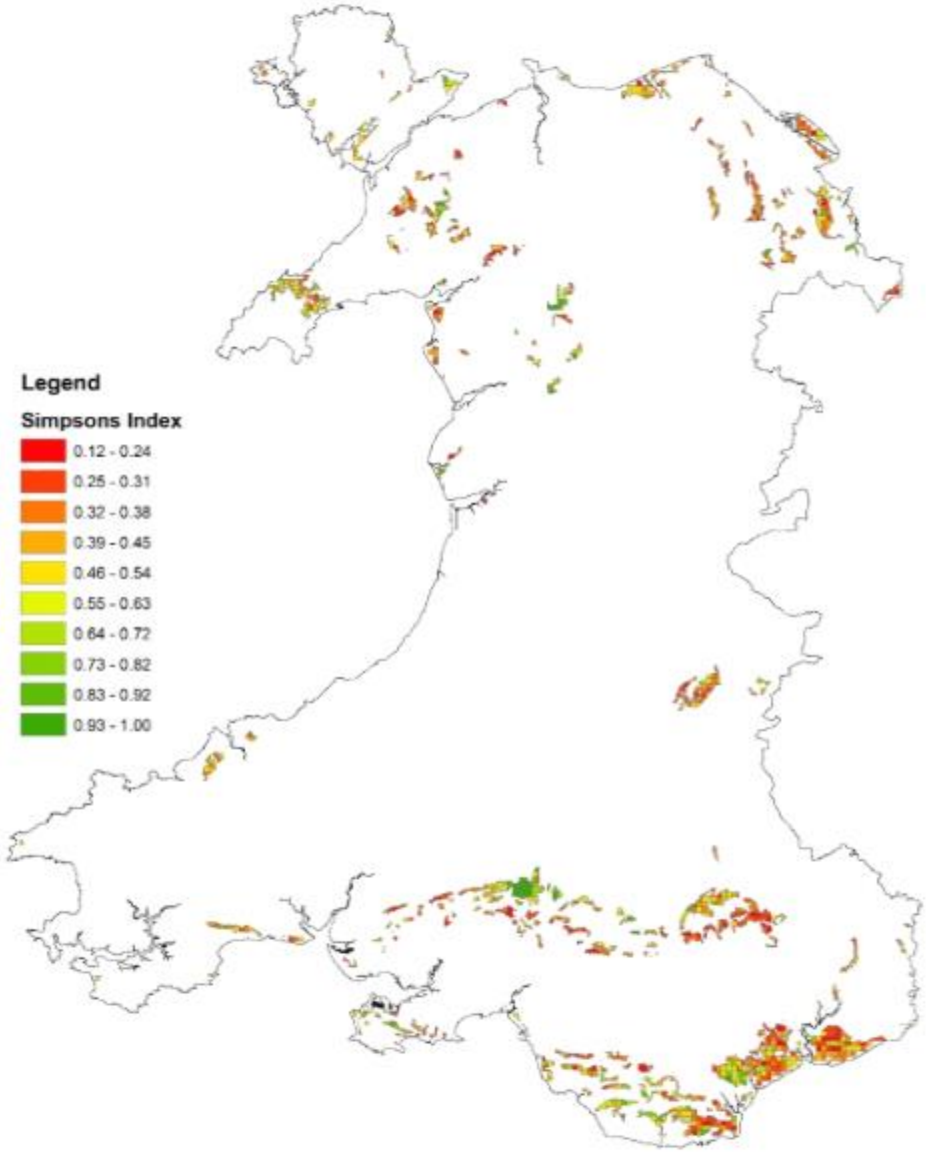

Figure 9.9.4.1d. *Land cover Simpsons Index in areas of rare and occasional soils (dominant method). In contrast to the Shannon Index, lower values indicate higher diversity with more weight given to areas where land covers are more evenly represented. Red areas identify rare or occasional soils with high levels of above ground biodiversity. These areas are found in almost all areas where rare and occasional soils are found.*

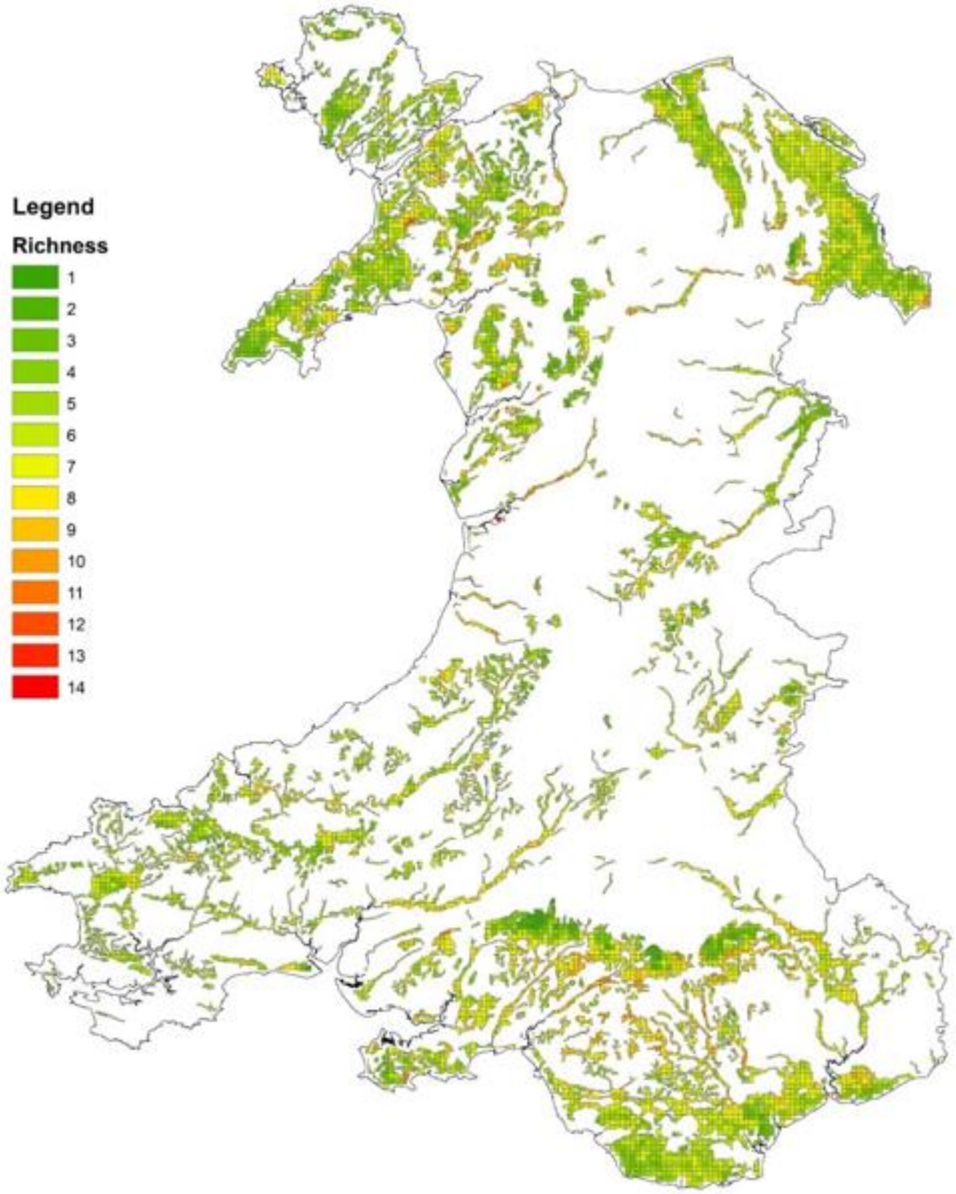

Figure 9.9.4.2a. *Land cover richness in areas of rare and occasional soils (estimated method). Areas of red indicate high above ground richness, determined by the number of different land covers within each 1km^2 square. Richness is generally low across Wales, with high richness in north-western regions, and moderate richness in the south. The highest richness is found in a single square located near the River Dyfi, north of Aberystwyth.*

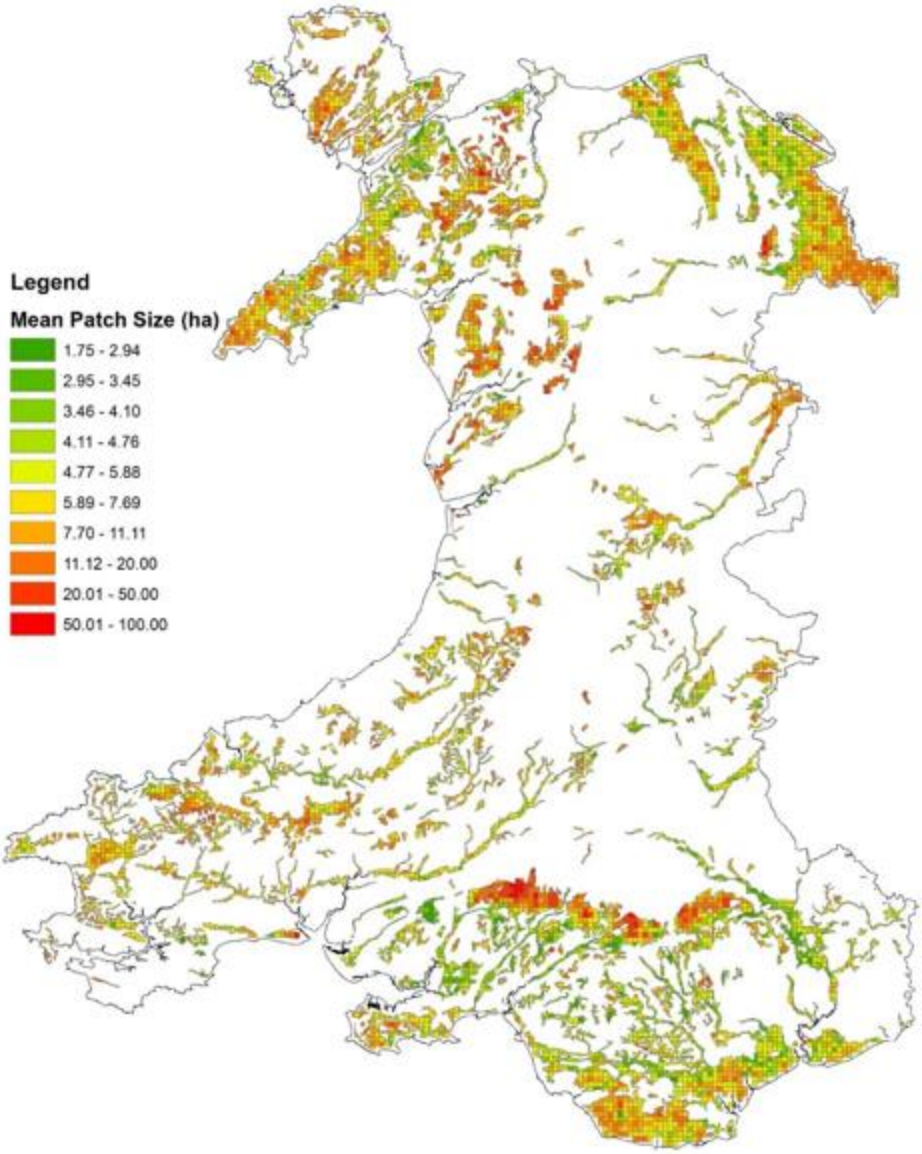

Figure 9.9.4.2b. *Land cover mean patch size (ha) in areas of rare and occasional soils (estimated method). Red squares indicate areas of larger mean patch size, and are widespread across Wales. Areas with higher richness generally have lower mean patch size.*

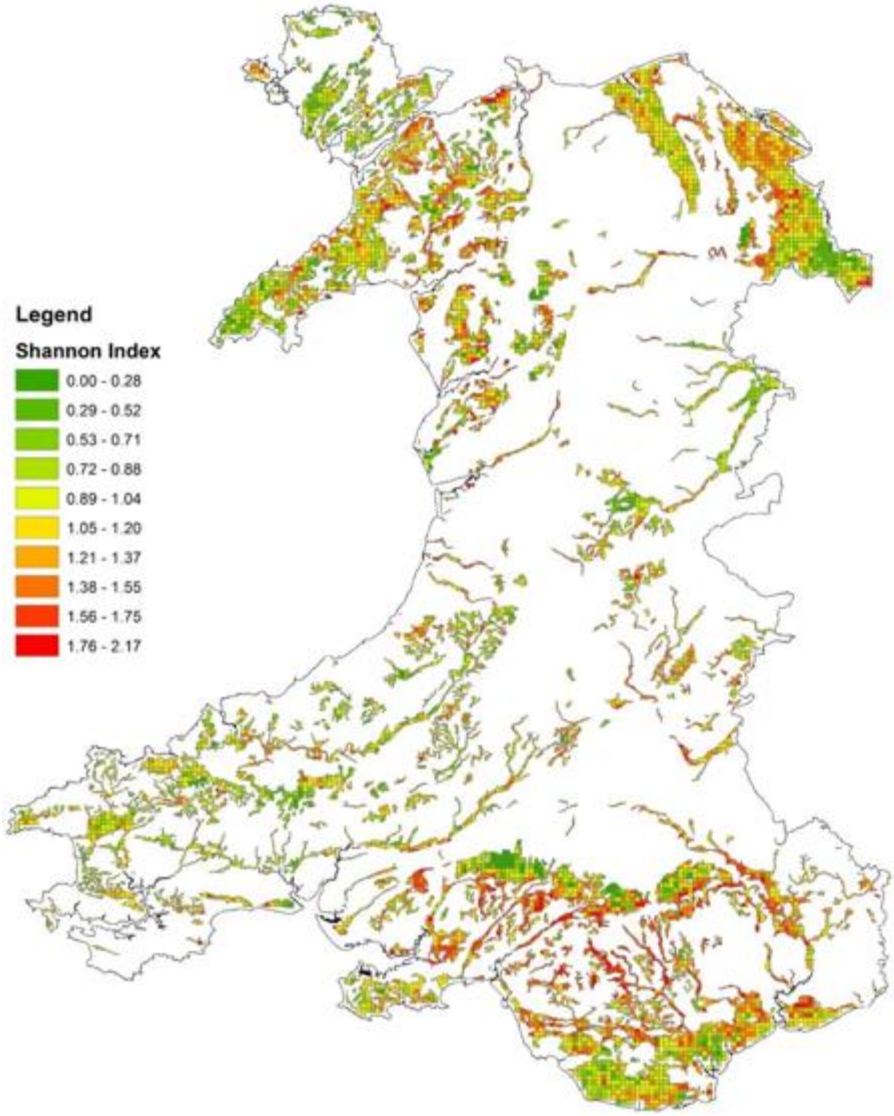

Figure 9.9.4.2c. *Land cover Shannon Index in areas of rare and occasional soils (estimated method). Larger values indicate higher diversity, with greater weight to areas with higher richness, regardless of whether one land cover is dominant. Red areas identify rare or occasional soils with high levels of above ground biodiversity. These occur ostensibly in the South Wales valleys, along the Llyn Peninsula, Snowdonia, Flintshire and the Clwyd River valley.*

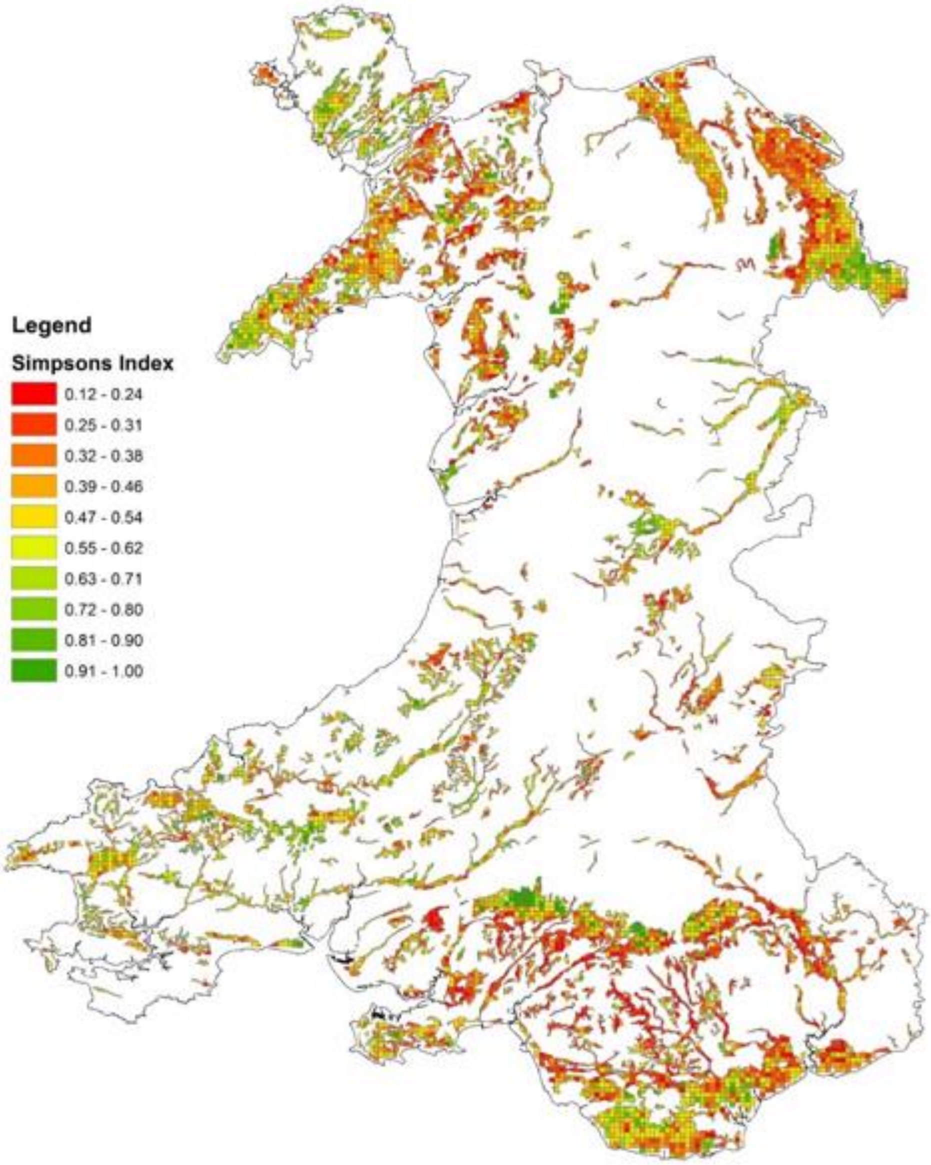

Figure 9.9.4.2d. *Land cover Simpsons Index in areas of rare and occasional soils (estimated method). In contrast to the Shannon Index, lower values indicate higher diversity with more weight given to areas where land covers are more evenly represented. Red areas identify rare or occasional soils with high levels of above ground biodiversity.*

	Total Area (ha)	*Area within SSSIs (ha)*	*Proportion of Soil within SSSIs*	*Percentage of total SSSI area*
Rare Soils				
10.2.4 Earth eutro-amorphous peat soils	*1659*	*642*	*0.39*	*0.25*
10.2.2 Earthy eu-fibrous peat soils	*665*	*632*	*0.95*	*0.24*
8.3.1 Typical cambic gley soils	*207*	*0*	*0.00*	*0.00*
6.5.2 Humus-ironpan stagnopodzols	*144*	*103*	*0.72*	*0.04*
Occasional Soils				
7.1.2 Pelo-stagnogley soils	*17459*	*312*	*0.02*	*0.12*
6.3.1 Humo-ferric podzols	*14899*	*6501*	*0.44*	*2.48*
5.7.2 Stagnogleyic argillic brown earths	*13444*	*122*	*0.01*	*0.05*
3.6.1 Typical sand pararendzinas	*13142*	*6688*	*0.51*	*2.55*
9.6.2 Permeable, seasonally wet raw made ground soils	*10474*	*161*	*0.02*	*0.06*
8.1.4 Pelo-calcareous alluvial gley soils	*9828*	*5922*	*0.60*	*2.26*
6.5.1 Ironpan stagnopodzols	*6950*	*2375*	*0.34*	*0.91*
5.5.1 Typical brown sands	*6898*	*211*	*0.03*	*0.08*
8.1.3 Pelo-alluial gley soils	*6837*	*696*	*0.10*	*0.27*
8.1.2 Calcareous alluvial gley soils	*4925*	*576*	*0.12*	*0.22*
3.1.3 Brown rankers	*3848*	*3635*	*0.94*	*1.39*
2.2.0 Unripened gley soils	*3846*	*1914*	*0.50*	*0.73*
8.2.1 Typical sandy gley soils	*3512*	*1392*	*0.40*	*0.53*
5.4.3 Gleyic brown earths	*2795*	*14*	*0.00*	*0.01*
4.3.1 Typical argillic pelosols	*2652*	*24*	*0.01*	*0.01*
8.7.1 Typical humic gley soils	*2294*	*389*	*0.17*	*0.15*
5.4.2 Stagnogley brown earths	*2282*	*9*	*0.00*	*0.00*
9.2.4 Well aerated raw made ground soils'	*2233*	*62*	*0.03*	*0.02*

Table 9.9.4.1 *Rare and Occasional Soils within SSSIs*

Average Values	Richness (no.)	Mean Patch Size (ha)			Shannon Index	Simpsons Index
All of Wales	***5.71***	***9.80***			***1.03***	***0.48***
Rare + Occasional Soils		***6.11***	***8.75***	***1.15***	***0.42***	
p-value		*0*	*0*	*0*	*0*	
Rare soils		***6.54***	***7.79***	***1.16***	***0.43***	
p- value		*0.0006*	*0.1061*	*0.0059*	*0.0346*	
Occasional Soils		***6.10***	***8.78***	***1.15***	***0.42***	
p-value		*0*	*0*	*0*	*0*	

Table 9.9.4.2 *Average above ground diversity metrics and corresponding significance value using two-sample t-test at 5% significance level. Note that smaller values for the Simpson Index indicate greater diversity.*

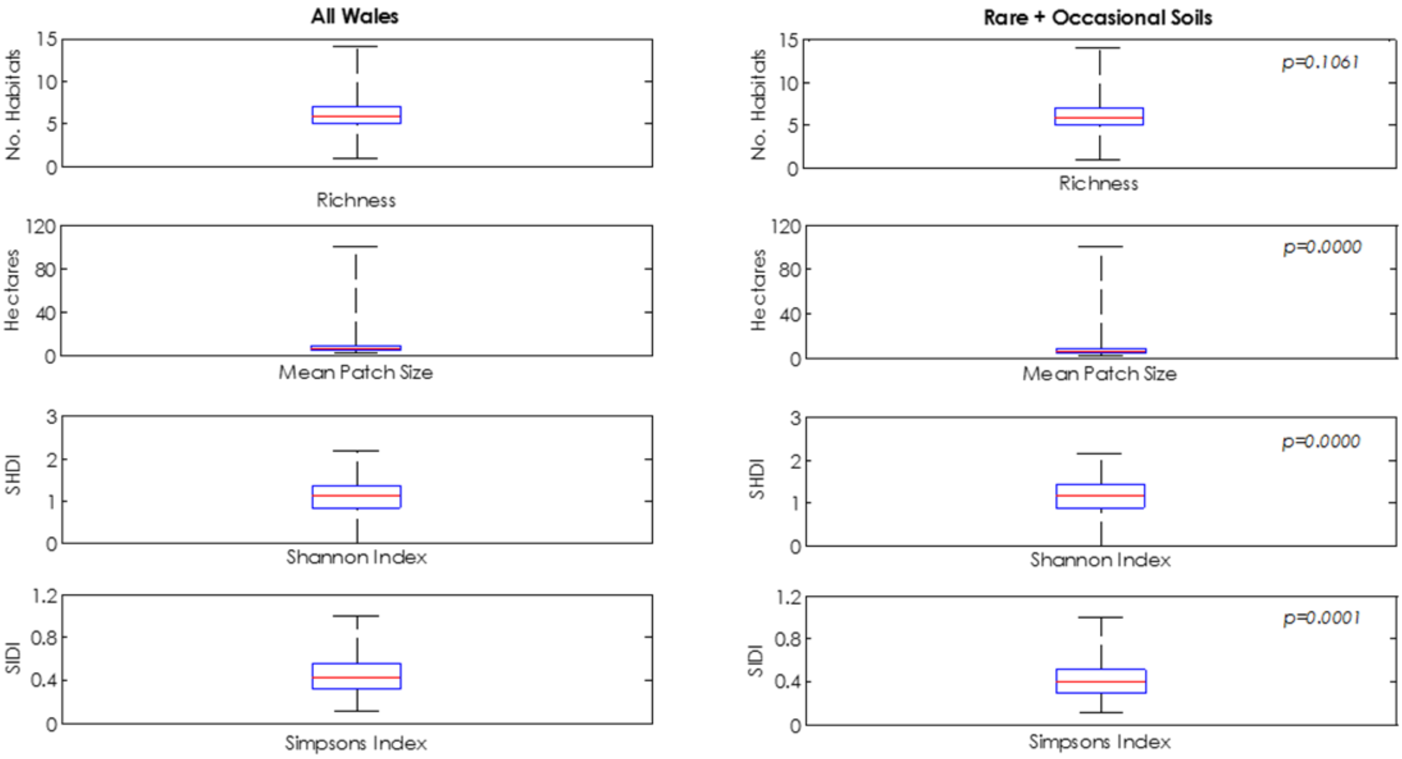

Figure 9.9.4.3 *Boxplots of habitat metrics for all of Wales compared to areas of rare and occasional soils (as determined from the dominant method). A two sample t-test is used to determine if there is any significant difference between above ground biodiversity metrics across all of Wales and that from rare and occasional soils. p-values indicate significance at the 5% level. While richness index is not significantly different compared to the Welsh average, mean patch size, Shannon Index and Simpsons index tends to be greater in areas of rare and occasional soils.*

9.9.5 Summary of soils work

We present several methods of potentially assessing soil contribution to high nature value. An initial assessment considers the abundance of Welsh soil groups in the context of global abundance according to the WRB (2006) classification. This indicates that even common Welsh soils are relatively unusual in the global context, especially the surface-water-gley soils and to a lesser extent the podzols.

We go on to make an assessment of Welsh soils based on rarity using two methods similar to those used for soil rarity assessment in Scotland.

We found that all of the rare or occasional soils are covered by SSSI's bar 1.
Whether rare soils should be included within the HNV assessment is something for the working group to decide.

9.9.6 Summary and Future for HNV metric

1. Methods for downscaling coarse resolution species data will be refined. This may be coupled with identification of datasets for rarer species where coverage is more consistent.
2. Further work is needed to explore how species data can best be incorporated into the metrics for Type 2 and 3 HNV farmland e.g. choice of metrics, methods for including them including that of rare soils.
3. The Woody Cover Product and linear density will be incorporated into the habitat metrics.
4. HNV approaches could assess whether land areas are also on rare or occasional soils resources? Moreover, it may be feasible to develop a bench marking scheme to assess areas such as catchments, to determine the abundance of rare or occasional soils and compare how their diversity levels compare to the national average.
5. Another thing to consider is whether it is useful/necessary to combine metrics with the single farm payment to ensure that only farmed land is included.
6. We have not yet incorporated farming intensity into potential HNV metrics, this could be done using NPP as a measure, work elsewhere (section) proposes a method for calculating NPP from NDVI. It would also be possible to incorporate data from the Agcensus or IACS e.g. stocking density
7. Decide which indicators to use to calculate HNV metric- potential indicators shown below and which datasets to use dependent upon spatial consistency and temporal repeatability.
8. As a first step a real-time participatory approach by the GMEP Advisory Group comparing outcomes from different combination of metrics using a web based data mapping tool CEH is developing which will be available in January 2016.

HNV Type 1	***HNV Type 2***	***HNV Type 3***
Proportion of semi-natural land	*Habitat diversity*	*Distribution of rare plant species*
Single farm payment?	*Habitat connectivity*	*Distribution of rare bird species*
Stocking density?	*Density of linear features*	*Distribution of rare and occasional soils*
	Plant species richness- possibly 1km resolution data available	*Protected areas*
	Bird species richness- tetrad resolution available- farmland birds or all birds?	*Area of priority Habitats?*
	Other species richness e.g. Ants, Bees, Craneflies, Carabidae, Centipedes, Millipedes, Cerambycidae, Hoverflies, Isopoda, Ladybirds, Fish, Orthoptera, Bryophytes- only available at 10km resolution	
	Distribution of rare and occasional soils	
	Single farm payment?	
	Stocking density?	

Table 9.9.6.1 Potential metrics for HNV

9. Once a final set of HNV metrics are produced they can be tested against other datasets such as:

- Agricultural management and farming system
- Protected areas
- Other types of Natural capital
- Glastir target layers
- Commons

For example, Figure 9.8.1.1 shows protected areas and protected zones for the Llyn Peninsula which if not used as part of the HNV metric could be tested for coincidence with the final HNV metrics when they are produced.

10. Finally, metrics for potential HNV farmland will be investigated in order to assess current versus potential future HNV farmland.
11. All of above will be discussed within an expanded HNV working group to include the whole GMEP Advisory Group to ensure consensus as to the final outcome across government, agencies and NGOs.